I. C. 7015 MAY 1938

UNITED STATES
DEPARTMENT OF THE INTERIOR
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BUREAU OF MINES
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INFORMATION CIRCULAR

GOLD MINING AND MILLING IN NORTHEASTERN OREGON

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BY

S. H. LORAIN

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

GOLD MINING AND MILLING IN NORTHEASTERN OREGON[1]

By S. H. Lorain[2]

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7015."

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INTRODUCTION

This paper is a preliminary report on recent lode gold mining activity, operating conditions, and mining and milling methods at properties in production in September 1936 in the gold belt of northeastern Oregon. A few inactive properties are described also. Districts, inactive in 1936, that have been important producers at some time in the past are mentioned briefly. This is one of a series of similar papers describing western mining districts.

The past production record of the gold mines of northeastern Oregon entitles the region to be ranked as one of the important gold-mining regions of the United States. Although comparatively inactive for many years, lode mining in the region has recently undergone a marked revival.

The material for this paper was obtained during a field trip in September 1936. At that time all lode-mining activity in the region was still definitely in the development stage. More detailed descriptions of mining and milling methods will be made in supplemental papers as operations become more firmly established.

ACKNOWLEDGMENTS

The author wishes to acknowledge his indebtedness to the operators of the region, who freely supplied such information as was available.

Officials of the Eastern Oregon Light and Power Co., of the Union Pacific Railway Co., of the U. S. Forest Service, and the U. S. Weather Bureau kindly supplied information relative to their respective activities in the region. The relief map of northeastern Oregon was supplied through the courtesy of the Oregon State Library.

In preparing this report, frequent reference has been made to publications by Lindgren[3], Pardee[4], Swartley[5], Hewett[6], and Gilluly, Reed, and Park[7]. Other sources of information are acknowledged later in the text.

H. E. Hendryx, Baker, Oreg., due to his broad knowledge of mining activities in the region, was of great assistance to the writer in covering such a large area in the limited time available.

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[3] Lindgren, Waldemar, The Gold Belt of the Blue Mountains of Oregon: Geol. Survey, 22nd An. Rept., 1900-1901, part 2, pp. 551-776.

[4] Pardee, J. T., Faulting and Vein Structure in the Cracker Creek Gold District, Baker County, Oreg.: Geol. Survey Bull. 380, 1908, pp. 85-93.

[5] Swartley, Arthur M., Ore Deposits of Northeastern Oregon. The Mineral Resources of Oregon: Oregon Bur. of Mines and Geology, vol. 1, no. 8, December 1914, 229 pp.

[6] Hewett, D. F., Zonal Relations of the Lodes of the Sumpter Quadrangle: Trans. Am. Inst. Min. and Met. Eng., 1931, pp. 305-346.

[7] Gilluly, James, Reed, J. C., and Park Jr., C. F., Some Mining Districts of Eastern Oregon: Geol. Survey Bull. 846-A, 1933, 140 pp.

LOCATION

The gold mines of northeastern Oregon are found in an area approximately 100 miles long from east to west, by 50 miles wide from north to south. (See fig. 1.) The region embraces the headwaters of the John Day River and most of the drainage areas of the Powder and Burnt Rivers. Most of the districts described are in Baker County, some of the western mining districts are in Grant County, and some of the southern districts are in Malheur County.

Baker, with a population of approximately 8,000, is the county seat of Baker County and the principal distributing point of the region.

HISTORY OF MINING

Gold was discovered in northeastern Oregon in 1861, by a prospector named Griffin, in Griffin's Gulch, a few miles southwest of the present site of Baker. The following year, the Auburn placers were discovered and Auburn, the first permanent settlement in the region, was founded. By 1864 virtually all mining districts in the region had been discovered. Supplies were brought 300 miles overland from The Dalles, on the Columbia River.

Many of the early placer diggings were rich; they are estimated to have produced over $40,000,000 in the first few years after discovery. By 1870 placer mining began to decline, and continued to do so until the introduction of dredges, about 1910, after which it increased slightly. In 1936 two large dredging companies were operating in Baker County and two were operating in Grant County; a number of small hydraulic or sluicing operations were working at various points throughout the region.

The first quartz mines were worked in 1865 and 1868 in the Susanville and Mormon Basin districts, and in 1872 at Connor Creek and Cable Cove. Ore or concentrates had to be shipped several hundred miles by pack horses.

The completion of the transcontinental railroad in 1885 marked the real beginning of quartz mining in the region. Eagle Creek and Cornucopia first became active about this time. After 1889 the increase in lode mining was rapid, culminating in a boom that lasted from about 1899 to 1908.

A period of rising prices caused by the World War brought a decline in gold mining that lasted until the recent depression. For several years prior to 1933, important lode-mining activities in the region were virtually nonexistent.

After the increase in gold prices in 1933, interest in lode gold mining was revived and a number of operators entered the field. By 1936, 7 or 8 mills of 50 to 100 tons daily capacity were producing bullion and concentrates, and a number of other properties were conducting exploration or development work in a businesslike manner.

During or just after the World War a few chromite and manganese deposits were worked on a small scale, and the copper deposits near Homestead produced a considerable tonnage of copper ore.

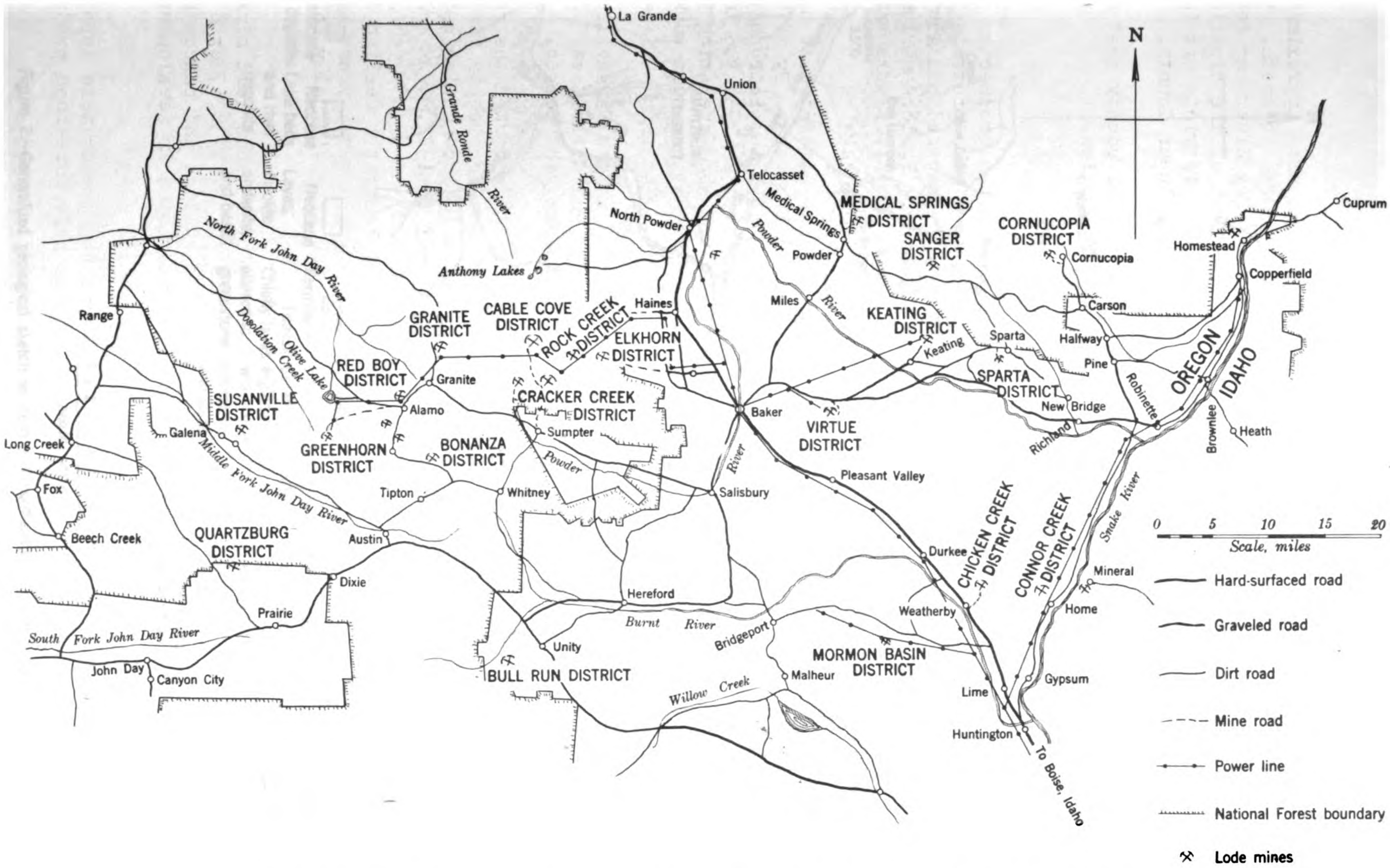

Figure 1.—Northeastern Oregon gold belt, showing general location of mining districts, roads, power lines, and National-Forest boundaries.

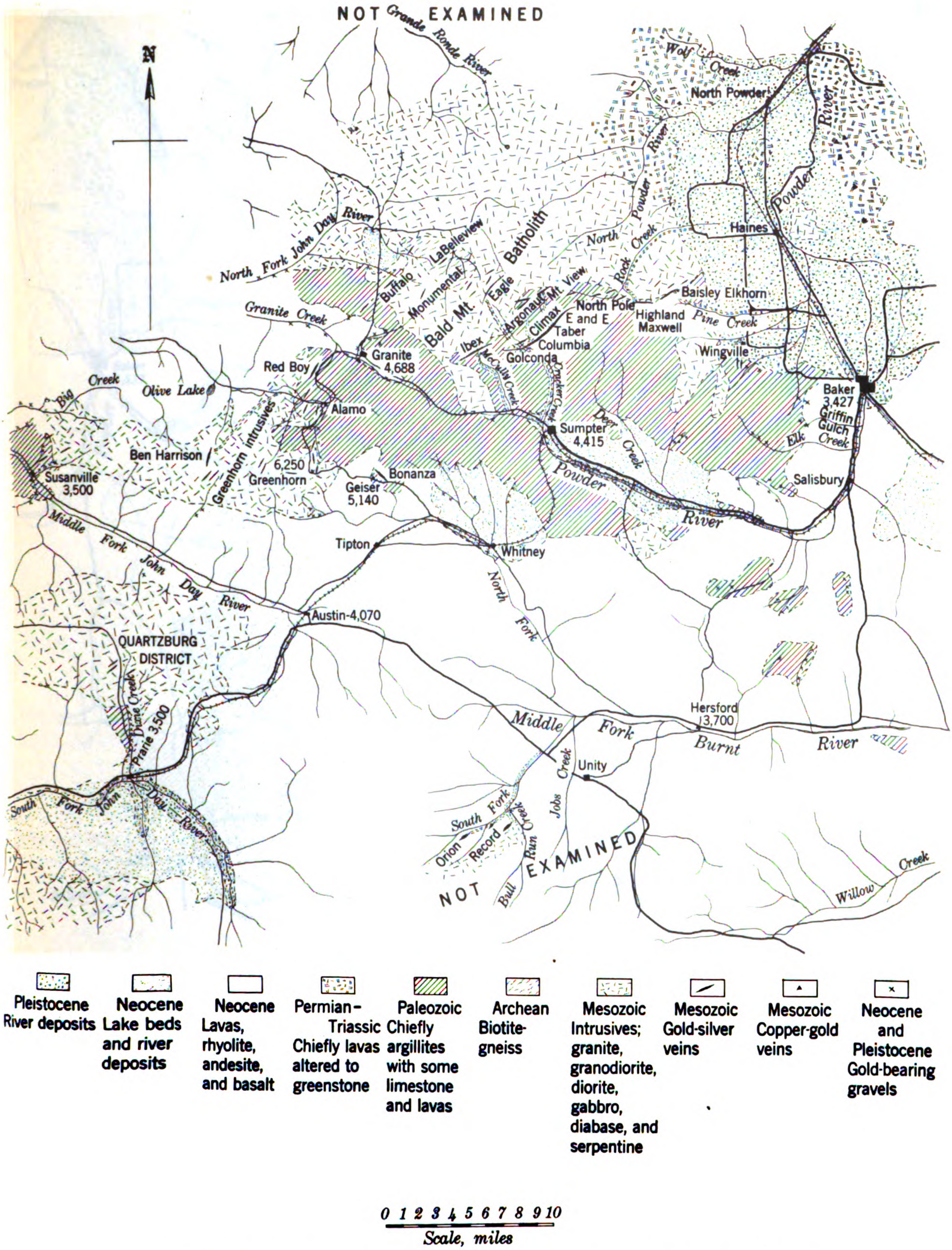

Figure 2.—Generalized geological sketch western end northeastern Oregon gold belt. (After Lindgren.)

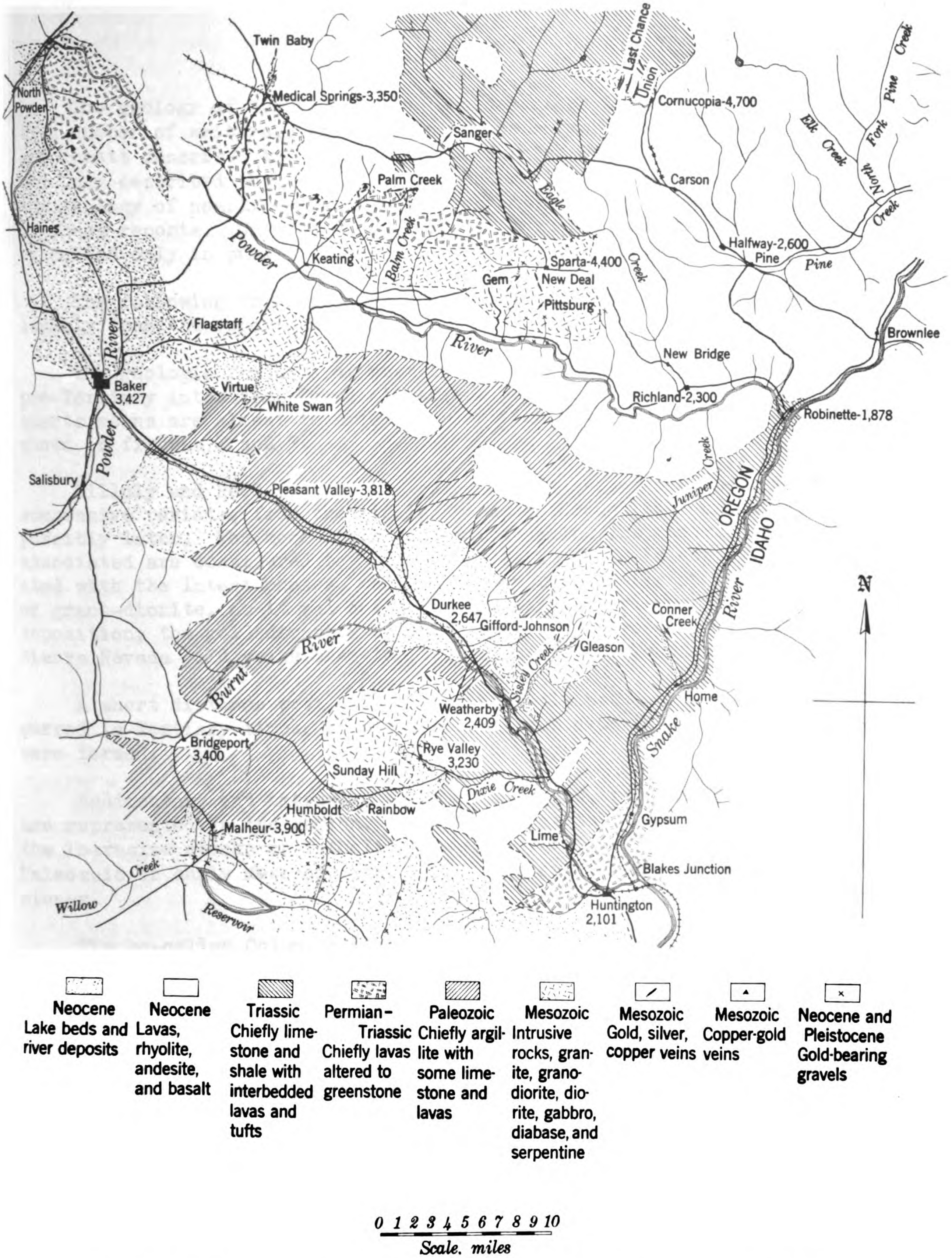

Figure 3.—Generalized geological sketch eastern end northeastern Oregon gold belt. (After Lindgren.)

GEOLOGY

The geology of the region has been described in considerable detail by a number of writers. In addition to the works already cited, Pardee and Hewett described the geology of the Sumpter quadrangle[8], and Grant and Cady described the geology of the Baker district[9]. A description of the geology of nearly every mine or prospect in the region can be found in these reports. Unfortunately, most of them are out of print and may be consulted only in public libraries or private collections.

The following brief summary of the general geology has been abstracted largely from the reports mentioned.

The geologic features of most interest to mining men are the bodies of pre-Tertiary intrusives found at various points throughout the region. The quartz veins are almost invariably associated with these intrusives, as shown in figures 2 and 3.

Gilluly and Reed were of the opinion that these rocks were intruded at successive periods, from the middle Triassic through the Jurassic and possibly later. The more basic phases with which the chromite deposits are associated are considered to be the earliest. The gold deposits are associated with the latest phases, which are composed chiefly of quartz diorite, or grano-diorite, as it was called by the earlier writers. In time of deposition, the gold deposits of this region are more closely related to the Sierra Nevada gold veins than to those of the Rocky Mountain area.

A short distance west of the area here discussed, ore deposition occurred in Tertiary times, when the quicksilver deposits of the Ochoco district were formed.

Sedimentary and extrusive rocks of all ages, from Carboniferous to recent, are represented in the region. Most ore deposits that are not actually within the intrusive stocks or batholiths are in argillites or altered lava flows of Paleozoic or early Mesozoic age. The lavas are usually referred to as greenstones.

The so-called Columbia River lavas, of Eocene age, overlie the older rocks in most parts of the region; in other parts, particularly in areas of pronounced uplift, the older rocks and the ore veins associated with them have been exposed by erosion. The exposed outcrops of intrusive rocks vary in size from small dikes and stocks to masses large enough to be termed batholiths. The wide distribution of these outcrops suggests that they may represent cupolas, or offshoots from a very large igneous mass underlying the entire region.

8/ Pardee, J. T., and Hewett, D. F., Geology and Mineral Resources of the Sumpter Quadrangle: The Mineral Resources of Oregon, Oregon Bureau of Mines and Geology, vol. 1, no. 6, October 1914, pp. 1-127.

9/ Grant, U. S., and Cady, G. H., Preliminary Report on the General and Economic Geology of the Baker District of Eastern Oregon: The Mineral Resources of Oregon, Oregon Bureau of Mines and Geology, vol. 1, no. 6, October 1914, pp. 131-161.

The ore deposits are nearly always found near the margins of the larger outcrops. Hewett has recognized a zonal arrangement of ores around the Greenhorn intrusives and the Bald Mountain batholith. He points out that ores of the outer zones contain relatively fewer sulphides and more free gold than the veins of the inner zones. This study has a very definite practical value to mine operators in the districts concerned. If similar relations exist elsewhere in the region, they have not been described. The large number of mines and prospects in the Greenhorn-Bald Mountain area was undoubtedly a great help in establishing a zonal classification. Detailed studies along this line in other districts might result in valuable deductions.

Sulphide mineralization throughout most of the area consists chiefly of pyrite, arsenopyrite, and chalcopyrite, frequently associated with galena, sphalerite, and tetrahedrite. In some places stibnite, various silver sulphides, and tellurides are found. In the "copper belt" of the northeastern part of the region there is a predominance of pyrite-chalcopyrite mineralization. Many deposits in this belt have been considered chiefly valuable for their copper content; others, such as the Cornucopia and, more recently, Balm Creek, are worked primarily for gold, although the ores carry varying amounts of copper.

Ore Deposits

Ore deposits in the eastern Oregon gold belt are predominantly of the quartz-vein type. The only important exceptions are the copper-gold deposits in greenstone and a few ore bodies of the impregnated shear-zone type in argillite; the latter usually are closely associated with quartz veins. Nearly all quartz veins of the region occupy fissures in quartz diorite, argillite, or greenstone.

The greater number of strong, persistent veins have been found in a dense, dark-colored argillite, which yields to movement only along a comparatively few, well-defined lines of fracturing. Nearly all the important veins in argillite are on fault fissures that show evidence of considerable movement The fissures are characterized by one or more strong seams of gouge in a wide zone of shearing; the quartz veins are usually found with the gouge in the most intensely sheared part of the fissure; in places the gouge and sheared argillite are sufficiently mineralized to form ore. Many of these fissures are traceable for thousands of feet; the North Pole-Columbia fissure has been traced for 5 or 6 miles. The strength of the fissure seems to bear a direct relation to the persistence of the ore shoots. A number of the stronger fissures have contained ore shoots 600 to 1,200 feet long; the North Pole-Columbia fissure contained ore bodies that were stoped almost continuously for nearly 2 miles along the strike.

It was noticeable in a number of veins of this type visited by the writer that striations indicated there had been a large horizontal component to the fault movements. Pardee's studies of the North Pole-Columbia lode proved that on that fissure the horizontal movement was over four times as great as the vertical movement. It is possible that a large horizontal movement was necessary to open channels for rising ore solutions in these gouge-filled fissures.

There are comparatively few gold quartz veins in greenstone in this region. In 1936 the Twin Baby mine in the Medical Springs district was the only operating mine on a gold quartz vein in greenstone. The Permian or Triassic greenstones usually are not found in the gold-mining districts, but are widely distributed across the "copper belt" and contain nearly all of the copper prospects. These copper, or copper-gold deposits occur as sulphide veinlets, disseminations, or replacements in shear zones or fault fissures in the greenstone.

On Virtue flats, east of Baker, there are some greenstones interbedded with Carboniferous argillites. This small area of greenstones contains the famous Virtue vein, the largest producer yet developed in the Virtue district. The Virtue ore shoot is a narrow though persistent quartz vein occupying a fault fissure in greenstone.

Probably a majority of the veins of this region occur in fault fissures or fractures in quartz diorite, or related intrusives. As a rule, these veins are shorter and weaker, but more numerous than the veins in argillite or greenstone. Nevertheless, the Cornucopia mine, which has been the largest individual producer in the region, and the Ben Harrison mine, which is the largest active producer in the western end of the region, are both in diorite.

It is noteworthy that the Cornucopia, Ben Harrison, and some others, occur in fractures along which there is little evidence of great movement. There is comparatively little gouge or crushed wall rock, and the quartz vein fills the fracture almost from wall to wall. Other veins in diorite are obviously on fissures formed by strong fault movement. In these fissures the quartz occurs as stringers or short lenses with large amounts of gouge and crushed wall rock. In the narrower fissures of this type, the ore bodies are likely to be small and uncertain, but good ore shoots have been found in fissures averaging 4 feet or more between the diorite walls.

A great many small and uncertain veins have been found in the region. However, there are a very considerable number of strong fissures that contain or have contained strong persistent ore bodies. A number of ore shoots with strike lengths of 500 to 1,200 feet have been worked.

The stronger quartz veins are uniformly between 2 and 8 or 10 feet wide; they probably average between 3 and 5 feet wide. The weaker and shorter veins as a rule are narrower; they vary from small stringers up to lenses 5 feet wide or more.

Ore bodies of the shear zone type, as found in the greenstone copper belt, may be 10 to 50 feet or more wide but have not yet been sufficiently developed to clearly demonstrate their size or persistence.

The Union vein, at the Cornucopia mine has been developed about 1,400 feet vertically below the outcrop and is still in ore. Other nearby parallel veins on Cornucopia ground outcrop 1,000 to 1,500 feet higher than the Union vein. The productive vertical range in this district has therefore been demonstrated to be at least 3,000 feet.

The North Pole-Columbia vein, 50 miles in a straight line southwest of the Cornucopia, has been mined over a vertical range of about 2,500 feet, from the highest outcrop to the bottom of the Columbia shaft. Inasmuch as Hewett's studies place this vein in the outer zone with respect to the Bald Mountain batholith, it might be expected that mineralization would extend to a much greater depth.

Numerous other veins have been mined to depths of 1,000 to 2,000 feet below the outcrop; in many cases the bottom levels are still in ore. It is apparent, therefore, that commercial mineralization extends over a vertical range which may be measured in the thousands of feet.

Individual ore shoots usually have persisted to a depth at least equal to their maximum strike length; frequently there appears to be a tendency for them to be more persistent in depth than on the strike, but this has not yet been clearly demonstrated. Apparently the North Pole-Columbia and the Red Boy ore shoots were striking exceptions to this rule; the stopes on these veins were long and shallow. There is some doubt that either of these ore shoots was actually worked out.

The ores of this region, in general, may be considered as medium to high-grade gold ores if compared with other veins of the intermediate temperature type. Most ore mined in the past has averaged between half an ounce and 1 ounce of gold per ton, with varying amounts of silver and copper. The lower limit doubtless has been governed largely by the cost of mining. Therefore, it is to be expected that ore of somewhat lower metal content will be mined in the future. Newly discovered ore shoots, however, should yield considerable quantities of high-grade ore.

TOPOGRAPHY

The topography of the region is illustrated by the relief map shown in figure 4.

The highest mountains in the region are found in the northeastern and northwestern parts, where a number of peaks rise to elevations of 8,000 to 9,000 feet or more above sea level. The Wallowa mountains in the northeast are precipitous, but the Greenhorn mountains, and other ranges in the northwest have a more mature topography; their slopes usually sustain a heavy growth of timber, except on the highest peaks.

Lower mountain ranges are found in various parts of the region, as shown on the map; all are part of the group of ranges known collectively as the Blue Mountains.

The basin-like areas shown on the relief map adjacent to the Powder River and Burnt River are between 2,000 and 3,000 to 4,000 feet above sea level. These areas are characterized by gently rolling hills and broad, level valleys.

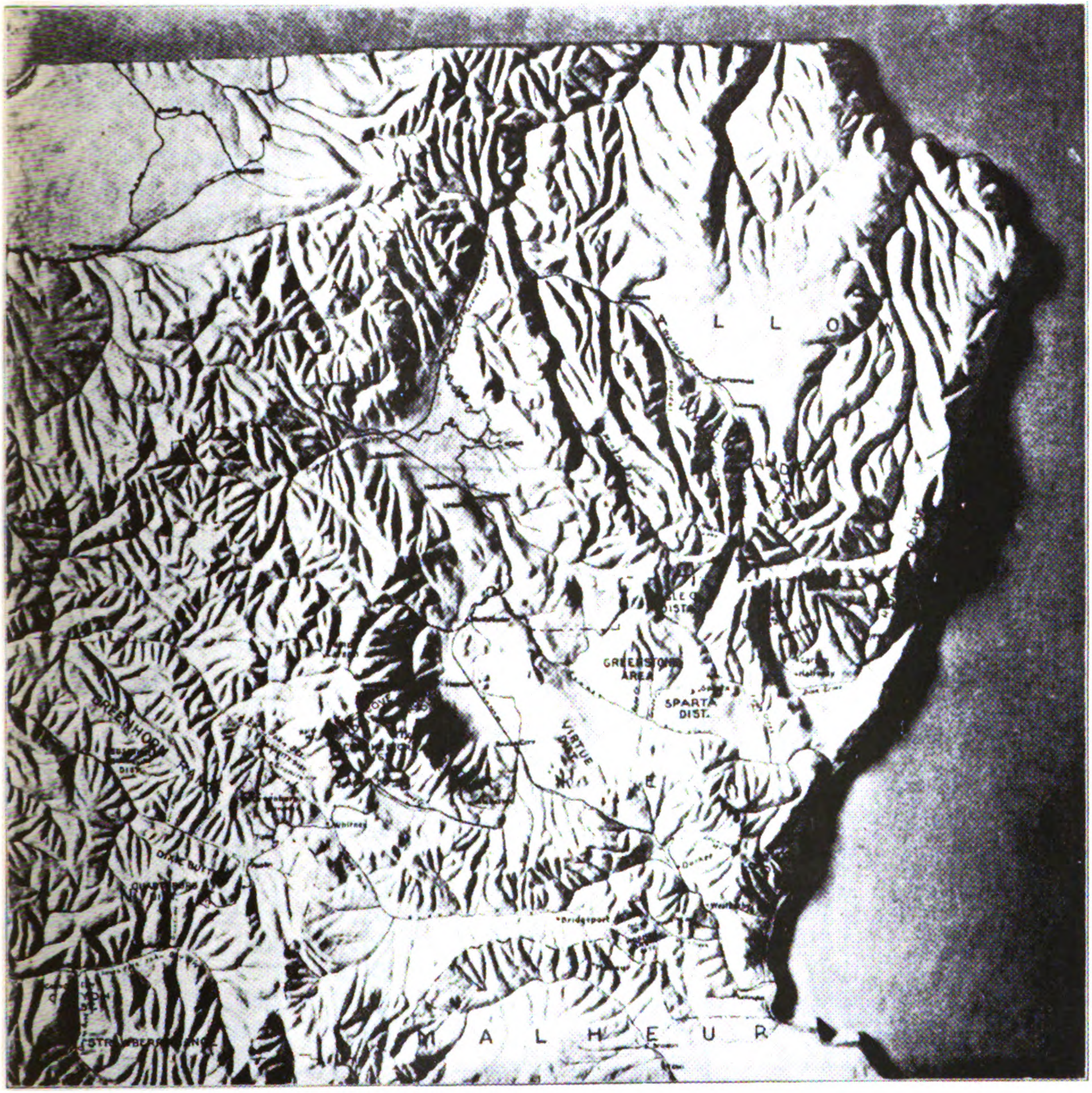

Figure 4.- Relief map of northeastern Oregon.

CLIMATE AND VEGETATION

Basically, the climate is semiarid throughout the region, but it is greatly modified by the topography in some localities. The comparatively low rolling country in the central part of the region and adjacent to the Burnt and Powder Rivers is characterized by light precipitation and sparse vegetation. The hills are sandy and rocky in appearance and are covered only with a scattered growth of sagebrush; farms and ranches, however, are found in the bottom lands adjacent to the permanent streams. In these areas the summers are hot and the winters moderate.

Timber begins to appear at elevations above 4,000 feet and becomes increasingly heavy as the mountains are approached. The precipitation in the higher mountains is several times greater than at Baker, permanent streams are abundant, and small-scale water-power developments are frequently possible. In these mountains the winters are long and the snow commonly attains a depth of 10 to 12 feet. On the other hand, the summer temperatures are moderate and nights are always cool.

The following tables, compiled from records supplied by the U. S. Weather Bureau, indicate climatic conditions at important points throughout the region.

Average precipitation, inches

Station	Baker	Columbia mine	Cornucopia	Sparta	Granite	Greenhorn	Ibex mine
Elevation	3,471	6,000	4,400	4,150	4,688	6,250	6,000
Years recorded	40	7	20	31	6	5	15
January	1.20	6.42	7.04	3.13	1.85	6.53	4.55
February	1.09	5.26	5.86	2.34	2.08	3.95	4.08
March	1.05	2.79	4.18	1.88	1.68	2.50	2.73
April	.98	1.51	3.44	1.24	.67	2.26	2.36
May	1.39	3.23	2.78	1.74	1.98	2.40	2.00
June	1.16	2.19	2.19	1.26	1.41	3.01	1.54
July	.50	1.10	.77	.60	.57	.69	.57
August	.52	.65	1.01	.61	.29	.79	.62
September	.70	1.28	1.78	.95	.92	1.16	1.20
October	.77	1.49	2.61	1.30	1.36	2.16	1.70
November	1.08	4.25	6.32	2.52	2.08	5.43	3.27
December	1.29	5.33	6.21	3.40	1.45	4.25	3.88
Total	11.73	35.50	44.19	20.97	16.34	35.13	28.50

Average snowfall, inches

Station	Baker	Columbia mine	Cornucopia	Sparta	Greenhorn	Ibex mine
Years recorded	38	8	22	34	5	15
January	11.0	63.1	75.0	30.6	77.1	54.9
February	7.0	53.4	52.0	23.0	48.7	47.1
March	5.6	24.5	28.2	14.6	24.2	29.9
April	1.6	7.3	14.2	4.5	17.1	15.9
May	.2	4.9	1.3	.3	5.3	5.4
June	T	1.0	.5	.2	.2	1.2
July	.0	T	.0	.0	T	.0
August	.0	T	.0	.0	T	.0
September	T	.7	.1	T	2.4	.5
October	.4	7.4	4.3	2.2	12.3	9.1
November	3.5	34.0	32.3	17.1	44.4	31.6
December	10.5	53.3	56.7	30.8	56.4	50.3
Total	39.8	249.6	264.6	123.3	288.1	245.9

Temperatures at Baker
based on 40 years records

	Average maximum	Average minimum	Highest	Lowest
January	32.5	17.4	55	-22
February	37.6	22.1	59	-20
March	46.1	27.6	74	-12
April	55.7	33.3	83	15
May	63.5	39.4	90	21
June	71.1	45.4	98	27
July	81.9	51.4	102	34
August	81.3	50.1	101	31
September	70.5	41.9	94	16
October	59.7	34.8	85	12
November	45.7	27.9	66	- 8
December	34.3	19.8	59	-24
Year	56.7	34.3	102	-24

Station	Years recorded	Latest date with temperature of 32° or lower in the spring	Earliest date with temperature of 32° or lower in the fall
Baker	40	Apr. 26 to June 17	Sept. 4 to Oct. 19
Granite	6	July 5 to July 29	Aug. 1 to Aug. 26
Sparta	27	Apr. 30 to July 3	Aug. 25 to Oct. 30

TIMBER

Virtually no timber grows below 4,000 feet above sea level. At greater elevations some timber may be found almost anywhere in the region. Where the slopes are not too steep, the mountainous areas generally are heavily timbered; the heavy stands of yellow pine support a logging industry which is one of the principal sources of income for the region.

Usually, the best stands of yellow pine are found below 6,000 feet altitude. Tamarack, lodge-pole pine, and other evergreens are abundant in favored locations up to 7,000 or 8,000 feet. Nearly all the heavily timbered areas are included in the Whitman National Forest (fig. 2).

Mines situated in untimbered areas are nearly always able to obtain sawed lumber from sawmills within 10 to 20 miles of the mine. In 1936 rough sawed lumber suitable for most mine purposes cost $18 to $20 a thousand board feet at the mill; the lower price was usually quoted for large orders or regular consumers. Cost of trucking from the mill to the mine varied from about $2 to $4 a thousand, depending on the distance. No mine reported a total cost of more than $22 a thousand for lumber laid down at the mine.

Round timbers delivered to mines in untimbered areas usually cost from $0.035 to $0.055 a linear foot, depending on the size of the timber. Mines situated in timbered areas were able to contract for mine timber cut on their own claims at $0.01 to $0.015 a linear foot.

One mine that operated a small sawmill on its own claims was cutting its own lumber at a contract price of $8 a thousand board feet. This was generally considered to be a reasonable cost for operating small mills of about 18,000 feet capacity where the skid distance was not more than one-fourth mile.

Stumpage for saw timber cut on National Forest land was about $1 per thousand board feet; for stull timber of 10- to 12-inch butts the stumpage was $0.01 to $0.015 a linear foot; and for poles suitable for lagging the stumpage was $0.005 a linear foot.

ACCESSIBILITY

Baker is on the main line of the Union Pacific Railroad, 342 miles east of Portland, Oreg. The lines of this railroad enter the region from the north following the valley of the Powder River to Baker, then pass over a low divide to the Burnt River valley, which they follow southeasterly to the Idaho boundary. A branch line from Blaker Junction follows the west side of the Snake River down to Robinette. The valley of the Powder River above Baker is traversed by a narrow-gage railroad to Sumpter; beyond Sumpter the railroad swings around the mountains to Prairie, on the headwaters of the John Day River. The Pondosa lumber mills, near Medical Springs, are connected with the main lines of the Union Pacific by a short branch.

By highway, Baker is 326 miles east of Portland, or 149 miles northwest of Boise, Idaho, on U. S. Highway 30, one of the main transcontinental routes. Hard-surfaced or graveled highways branch out from Baker to the more important towns of the region. Many of the mining districts are close to these highways or may be reached easily on dirt roads at comparatively low elevations, where year-round transportation is usually possible.

Mountain roads, which are passable to motor transportation in the summer and early fall, extend from the main highways into most parts of the mountain districts. These roads are seldom, if ever, passable to wheeled motor vehicles during winter and early spring; freight must be hauled over them by tractor or horse-drawn sled during about half the year. These roads will be mentioned in more detail under the descriptions of individual mining districts.

Concentrates from nearly all districts in the region are hauled by road to Baker, where they are transhipped on the railroad to smelters. Mines in the Cornucopia district ship from Robinette; mines adjacent to the lower Burnt River ship from the most convenient point.

TRUCKING COSTS

Trucking costs were generally very uniform throughout the region. One-way freight hauls from nearly every mine operating in the region cost betweer $0.10 and $0.12 per ton-mile, including handling charges. Where it was possible to obtain a return load, the costs were between $0.05 and $0.06 per ton-mile. Usually concentrate shipments are much greater than return freight shipments. Very few data were available on the cost of winter hauling by sled. One mine, with a long sled haul, reported a cost of about $0.25 per ton-mile; another mine, with a comparatively short sled haul, all of which wa downhill, reported a cost of about $0.15 per ton-mile for this part of its haul. Winter hauling by truck cost about the same as summer hauling.

RAILROAD FREIGHT RATES

All concentrates except those of the Cornucopia mine, which shipped fror Robinette, were shipped from Baker. The following freight rates were in effect in September 1936:

Freight rates per ton on ore and concentrates from Baker, Oreg., to Tacoma, Wash.

Value of ore	40,000-pound car	100,000-pound car
$30.00[1]	$5.00	$4.00
40.00	5.50	5.00
50.00	6.00	5.50
60.00	6.50	6.00
70.00	7.00	6.50
80.00	7.50	7.00
90.00	8.00	7.50
100.00	8.50	8.00
350.00	9.25	9.25
600.00	13.00	13.00

[1] Per ton or lower.

Rates to Salt Lake City were $0.50 per ton higher than to Tacoma.

Rates to Kellogg, Idaho, were $1 per ton lower than to Tacoma on 40,000-pound cars; on 100,000-pound cars the rate was $0.50 per ton lower on $30-ore, but was the same as the rate to Tacoma on ore assaying more than $30 per ton.

SMELTERS

Concentrates may be shipped from Baker, 481 miles to the smelter at Tacoma, Wash.; 554 miles to the smelters at Salt Lake City, Utah; or 398 miles to the smelter at Kellogg, Idaho. There is very little difference in the freight rates to the three places. Shipments usually are made to the smelter that can handle the particular ore to best advantage. Gardner and Allsman[10] recently compiled tables of smelter rates in effect at most western smelters and presented a concise discussion of the factors affecting smelter charges.

LABOR AND WAGES

The region is slightly handicapped by a shortage of experienced mine labor. During the period when the larger mines were inactive most of the experienced miners drifted away. There is no nearby mining community from which to recruit a fresh supply, nor are operations yet large enough to attract miners from other districts. Consequently, most mine labor must be recruited from the farms and lumber camps. As a result, wages are slightly lower than in most other mining districts. In 1936 there was no standard wage scale; each mine paid wages that depended, to some extent, upon working conditions and upon the location and living conditions at the mine. However, practically all wages in 1936 were within the limits indicated below:

Miners and millmen	$4.00	to	$4.50	per day.
Muckers and laborers	3.50	to	4.00	do.
Shaftmen and skilled workers . . .	4.75	to	5.25	do.
Bosses	5.00	to	6.00	do.

General wages throughout the region are determined chiefly by the wages paid on farms and in the logging industry. Therefore, mine wages are not likely to be as sensitive to advances in base-metal prices as they are in most mining districts.

POWER

Electric Power

Power lines of the Eastern Oregon Light & Power Co. extend across the northern part of the region (fig. 1) and serve a number of the more important mining districts. A few districts in the extreme south and southeastern parts of the region are within reach of lines of the Idaho Power Co. In 1936 the following schedule of power rates was in effect on the lines of the Eastern Oregon Light & Power Co.

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[10] Gardner, E. D., and Allsman, Paul T., Open Schedules for Gold and Silver Ores and Concentrates at Western Custom Smelters: Information Circular 6926, Bureau of Mines, 1926, 25 pp.

"Rate P-1-a.

The following rate shall apply to service supplied from substations owned and operated by the Company and metered at the secondary voltage of the substation.

Demand charge:

First 50 hp. of maximum monthly demand	$2.00	per hp.
All over 50 hp. of maximum monthly demand . .	1.75	per hp.

Energy charges:

First 50 kw.-hr. per hp. of monthly demand included in demand charge.			
Next 75 kw.-hr. per hp. of monthly demand	. .	1.5¢	per kw.-hr.
Next 100 do.	. .	1.2¢	do.
Next 75,000 do.	. .	1.0¢	do.
All excess do.	. .	0.8¢	do.

Rate P-1-b.

The following rate shall apply to service supplied to consumer-owned substations at transmission-line voltages.

Demand charges:

First 50 hp. of maximum monthly demand	$1.75	per hp.
All over 50 hp. of maximum monthly demand . .	1.60	do.

Energy charges:

First 50 kw.-hr. per hp. of monthly demand included in demand charge.			
Next 75 kw.-hr. per hp. of monthly demand	.	1.5¢	per kw.-hr.
Next 90 do.	.	1.2¢	do.
Next 60,000 do.	.	1.0¢	do.
All excess do.	.	0.8¢	do.

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Maximum demand:

Where hoist motors (motors operating any crane or electrical hoist) are not used, the maximum monthly demand will be the highest average 15-minute load, as shown by the company's meters. Where hoist motors are used, the demand for billing purposes shall be the combined load of all hoist motors, in excess of the registration of such hoist motors in the average 15-minute load, plus the highest average 15-minute load as shown by the company's meters. Peaks due to accidents, which the consumer could not have guarded against, will be disregarded."

Diesel Power

With the exception of one mine, which had its own hydroelectric power plant, all of the larger mines that were not close to electric power lines were using Diesel power. Such costs as were available at the time indicated that these mines were producing power for between 1-1/4 and 1-1/2 cents a kilowatt hour, including repairs and depreciation.

The average fuel-oil consumption of six plants using various makes and models of Diesel engines of 75 to 200 horsepower was approximately 0.05 gallon per horsepower hour. At this time, a good grade of Diesel oil was selling for 8-1/2¢ a gallon, delivered within a radius of 10 miles of Baker. For each 5 miles beyond the 10-mile zone, an additional delivery charge of one-fourth cent per gallon was made.

GREENHORN, RED BOY, ALAMO, AND BONANZA DISTRICTS

The veins of these districts are considered by Hewett to bear a zonal relation to the Greenhorn intrusives, around which they are centered. All lie within a mountainous, heavily-timbered area southwest of the small town of Granite; they may logically be considered together.

Granite is reached by graded mountain road 15-1/2 miles from Sumpter. This road crosses a mountain pass at slightly over 5,500 feet elevation.

Beyond Granite the road is ungraded but, in good weather, is in fairly good condition throughout. A little over 6 miles from Granite the road forks. One branch turns south and east to Geiser and Whitney, 14 miles; the other continues in a general southwesterly direction 8 miles to the Ben Harrison mine at 6,200 feet elevation.

Most veins of the Red Boy, Alamo, and Bonanza (or Geiser) districts are in Paleozoic sedimentaries, chiefly argillite, along the eastern edge of the Greenhorn intrusives. There have been two important producers in these districts. The Red Boy is estimated to have produced gold and silver valued at about $1,000,000; the Bonanza, according to Swartley[11], produced about $1,750,000 between 1892 and 1904. These are said to have been quartz veins in fault fissures in argillite. The veins averaged 5 to 7 feet wide, and 70 to 85 percent of gold was free milling; the Red Boy bullion was 520 fine and Bonanza bullion 750 fine. According to Swartley, the Red Boy vein was stoped 800 feet along the strike but was mined economically for only 300 feet in depth. The Bonanza is said to have been developed 1,250 feet below the outcrop; information as to the size of stoped area is not at hand.

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[11] Work cited (see footnote 5).

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A few veins of the Greenhorn district are in argillite, but most of them are within the Greenhorn intrusives. Of the latter, a number are in gabbro or serpentine; so far these have not been highly productive. The Ben Harrison mine is in the quartz diorite that forms the backbone of Greenhorn ridge. Prior to present operations, it is estimated to have produced about $350,000 in gold and silver. In 1936 it was the only producing mine in the Greenhorn district.

Greenhorn and adjacent districts differ from other parts of the northeastern Oregon gold belt in the high percentage of silver in the ores. In some veins the value is chiefly in silver. Silver-bearing tetrahedrite may be the only important sulphide mineral in the straight silver veins. In other veins the sulphide mineralization comprises chalcopyrite, pyrite, galena, and sphalerite. In the Ben Harrison and some other veins, aresonopyrite and stibnite are important. Zonal relations within the area have been indicated, but not described in detail by Hewett[12].

Water and timber are abundant in the region and a commercial power line traverses the northern part. However, access to the region is difficult. Concentrates must be trucked 50 or 60 miles to Baker or trucked to Whitney, shipped on the narrow gage to Baker, and reshipped on the standard gage. In winter, freight can be hauled between Sumpter and the mines by sled only. Some trucking costs are given under the following description of the Ben Harrison mine.

Ben Harrison Mine

The Ben Harrison mine, after being idle for a number of years, was recently reopened by the Campbell-Oregon Mining Co., Geo. M. Henderson, manager.

An ore shoot 300 to 400 feet long was mined by earlier operators to a depth of about 450 feet below the outcrop, or about 300 feet below the adit level. Some ore had been developed, but not mined, 100 feet lower on the 600-foot level. The Campbell-Oregon company is deepening the shaft and driving levels at 100-foot intervals. When visited, preparations were being made to mine ore left by earlier operators above the adit level in addition to ore from lower levels.

The ore shoot is a strong quartz vein between quartz diorite walls. The walls are clean-cut; the gouge seams along the vein walls are comparatively thin. A portion of the vein contains numerous inclusions of sericitized quartz diorite. The vein is from 2 to 10 feet wide. According to Swartley, a maximum width of 21-1/2 feet was recorded. The average width is probably 4 to 5 feet.

The vein strikes N 3° E and dips 80° east in the upper workings but flattens to 55° in the lower levels. Sulphide mineralization comprises pyrite, arsenopyrite, chalcopyrite, and some stibnite and tetrahedrite. It was stated that gold is found chiefly with the arsenopyrite. The ratio of

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[12] Work cited (see footnote 6).

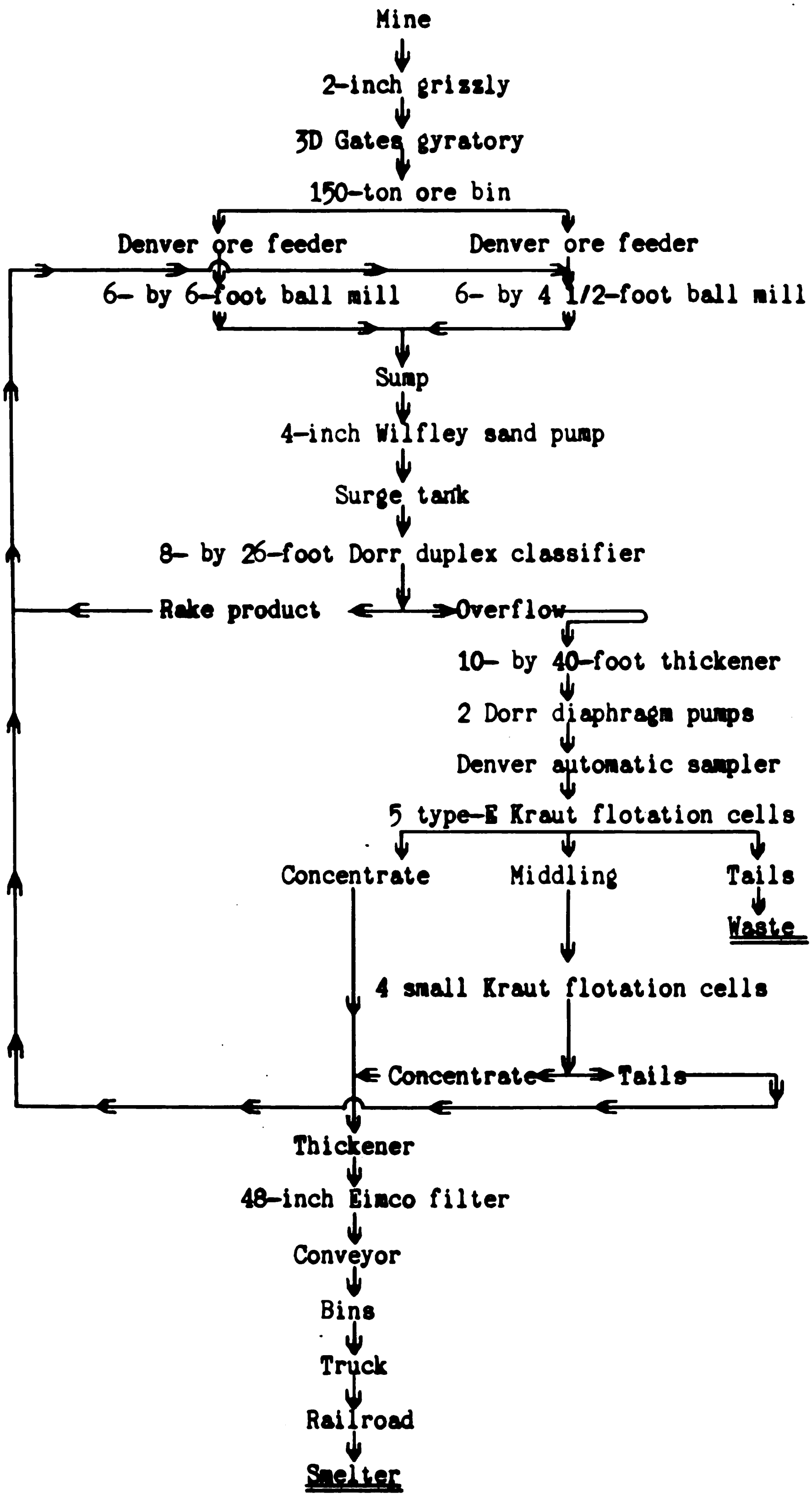

Figure 5.- Flow sheet of Ben Harrison mill (daily capacity, 100 tons).

gold to silver appears to vary widely from place to place. Swartley[13] stated that gold and silver occur in equal value; Hewett[14] gives the ratio of silver to gold at 50 to 1; when the mine was visited in 1936, the ratio of silver to gold was said to be averaging about 5 to 1.

Swartley[15] stated (1914) that the average value of ore in the upper workings was a little over $10 a ton, but that the ore developed on the 600-foot level was 19 to 20 percent higher in grade.

The mine is completely equipped. A 700-cubic foot, 125-horsepower, Sullivan WJ3 compressor supplies compressed air for mining. A 500-cubic foot compressor is in reserve. The shaft is provided with a 50-horsepower single-drum hoist of 500 pounds capacity. Other equipment includes a small sawmill, a 100-ton flotation mill, bunkhouses, and the necessary shops and miscellaneous equipment.

A 5- by 10-foot, 2-compartment shaft is being sunk at the rate of about 3 feet per day of three shifts. Two miners per shift are employed in the bottom. The shaft and adjacent workings were making about 30 gallons of water a minute. Over-all costs are approximately $40 a foot.

The upper part of the shaft is vertical; as the vein flattened, the shaft was inclined to conform to the dip.

A flat-back, open-stope mining method with stull support is used. Development raises are spaced about 200 feet apart. Where possible, flat holes are drilled with mounted jackhammer. Otherwise, self-rotated stopers are used. Detachable bits are used throughout.

The mill flow sheet is shown in figure 5.

Mine ore is dumped on a 2-inch grizzly; the oversize goes to a 3D Gates gyratory crusher set for 1-1/2-inch discharge. Grizzly undersize and crusher product go to a 150-ton ore bin.

Crushed ore is fed by two Denver feeders to a 6- by 6-foot and a 6- by 4-1/2-foot ball mill in closed circuit with a Dorr duplex classifier. Three pounds of forged-steel balls are consumed per ton of ore ground.

Classifier overflow, at 150 mesh, goes to a 10- by 40-foot thickener, from which the pulp is discharged at about 40 percent solids by two diaphragm pumps. The pulp flows to the first of a series of 5 Kraut flotation cells. A finished concentrate is taken from the first cell. A tailing is taken from the last cell and discharged to the tailing dump. Froth from the other four cells goes to a series of four small Kraut cells, which produce a finished concentrate and a tailing that is returned to the ball-mill circuit.

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[13] Work cited (see footnote 5).
[14] Work cited (see footnote 6).
[15] Work cited (see footnote 5).

Flotation reagents are pentasol xanthate (0.12 pound per ton) and pine oil. Xanthate is fed to the second and fourth cell of the first series of cells; pine oil to the fourth cell.

Concentrates are thickened in a Denver thickener and filtered in an Eimco 48-inch filter. The filter cake, containing 12 to 14 percent moisture, is conveyed to concentrate bins, trucked to Baker, and shipped by railroad to the smelter. The recovery was high on unoxidized ore; the ratio of concentration was said to be about 20:1.

In summer, concentrates are trucked 60 miles to Baker and freight returned. The cost is $6.50 per ton for trucking, plus a $0.50 handling charge. In winter, concentrates must be hauled 30 miles to Sumpter by tractor and sled, then trucked the remaining 30 miles to Baker. The cost of tractor haulage may be estimated at $7 to $8 a ton, winter truck haul $3.00 to $3.50 a ton, giving a total of $10 to $12 per ton for winter freighting between the mine and Baker.

The average year-round cost for trucking freight is $9 per ton.

When visited, the mine had been in operation only a short time and had not reached its peak. Therefore, the following costs may not be indicative of future trend.

		Cost per ton
Mining:		
Drifting, per foot	$8.00	
Raising, per foot	6.00	
Stoping, per ton	1.50	
Total mining		$2.35
Milling		1.50
Freight and treatment		1.50
Direct operating		5.35

GRANITE DISTRICT

The mines of the Granite district are found in an area several miles wide and extending from the Cougar mine, 3 miles northeast of Granite, to the LaBelleview mine, about 6 miles northeast of the Cougar. The Cougar is at an elevation of about 5,300 feet; the LaBelleview at 6,500 to 7,000 feet.

With the exception of the Monumental and LaBelleview, all of the better known veins occupy northeasterly striking fissures in argillite.

The Monumental is in the quartz diorite of the Bald Mountain batholith; the LaBelleview is in schist and gneiss in a small roof pendant. From southwest to northeast the character of the mineralization varies from that typical of the outer zone of Hewett's classification to that typical of the inner zone. Some of the fissures are strong and persistent. Ore shoots up to several hundred feet long are said to have been developed.

The total estimated production of the district is about $800,000. There was no important activity in 1936.

CABLE COVE DISTRICT

The Cable Cove district is northwest of the Cracker Creek district, about 11 miles by road from Sumpter, at an altitude of 7,000 to 8,000 feet.

The veins are within the Bald Mountain batholith. The ore bodies are quartz lenses or veins and disseminations of sulphides with diorite breccia and gouge along fissures in quartz diorite. The district is characterized by a great number of northeasterly striking fissures; many are short and weak; the Eagle fissure, is said by Lindgren[16] to be traceable for several miles.

The sulphide mineralization comprises chiefly arsenopyrite, pyrite, galena, sphalerite, and chalcopyrite. The ratio of gangue to sulphide is low, probably about 10:1.

The Imperial Eagle, California, and Last Chance are the best known mines; their combined production is about $150,000. The district was inactive in 1936.

CRACKER CREEK DISTRICT

The Cracker Creek district is here considered as embracing the northeasterly striking veins that parallel the edge of the Bald Mountain batholith from the Ibex mine northeasterly to the Mountain View mine, an airline distance of about 8 miles. Parts of this area have been referred to as the McCully district and Bourne district, but there is at present little reason for such a division.

The district is reached from Sumpter by fairly good dirt roads, 7 miles up Cracker Creek to the North Pole-Columbia lode, or about the same distance up McCully Creek to the Ibex mine. From these points, other mines of the district may be reached by trail or by steep mountain roads, some of which are passable by automobile in good weather.

The district is mountainous, heavily timbered, except at very high elevations, and contains many permanent streams. Power lines of the Eastern Oregon Light & Power Co. pass through the heart of the mineralized area.

The veins of the Cracker Creek district occupy steeply dipping fault fissures in argillite. The fissures are roughly parallel to the southeasterly edge of the Bald Mountain batholith; many of the fissures are very strong and persistent.

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[16] Work cited (see footnote 3).

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The total estimated production of the lode mines of the district is over $9,000,000, most of which was produced by the mines along the North Pole-Columbia lode.

In 1936, development was in progress at the Ibex, Climax, Argonaut, and Mountain View mines. Some shipping ore was being produced from the Golconda mine by leasers.

North Pole-Columbia Vein

The North Pole-Columbia fissure is said by Lindgren and others to be continuously traceable for over 5 miles. Important ore shoots have been worked for a continuous distance of about 10,000 feet along the strike, from the North Pole mine on the northeast through the E. and E. and the Taber Fraction to the Columbia mine on the southwest. About a claim length southwest of the Columbia is the Golconda mine, with about 1,200 feet of nearly continuous stoping. Therefore, the over-all productive length of the vein has been more than 12,000 feet. The most productive part of the vein strikes N. 25° to 40° E. South of the Columbia the fissure swings more to the west; north of the North Pole it swings to the east. At the Columbia shaft the vein dips about 86° southeast.

According to Pardee[17], the vein fissure is a normal fault with a vertical displacement of 400 feet and a horizontal displacement of about 1,800 feet. The zone of shearing is from 20 to 100 feet wide in most of the mined area; in the upper levels of the Golconda there is said to be a shattered zone 200 feet wide.

The ore is usually confined to one or two bands of a composite vein comprising several bands of quartz and silicified argillite separated by gouge or sheared argillite. In places the quartz is said to have been 40 feet wide. So far as can be learned from old records, the ore varied from a few inches to 25 feet wide; the average width was 3 to 4 feet. According to Lindgren[18], the ore in the Golconda differed from ore in the other mines in that comparatively little quartz was present; the ore consisted chiefly of fine grained impregnations of sulphides and free gold in shattered and brecciated argillite.

The principal sulphide mineralization is arsenopyrite and pyrite. Small amounts of tetrahedrite, stibnite, marcasite, and some tellurides have been found. Hewett[19] assigns the vein to the outer zone of deposition, with respect to the Bald Mountain batholith, but considers the northeastern end to be practically within the intermediate zone; he states that fewer sulphides and more free gold are in the Columbia ores than in the North Pole ores. As nearly as can be determined from the meager records available, the ratio of concentration of unoxidized ore did not exceed 25:1. On the basis of Hewett's studies, the ratio of concentration would be expected to decrease with depth. The ratio of silver to gold varied from about 1:1 to about 5:1. The maximum recovery of free gold by amalgamation was 40 to 50 percent.

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[17] Work cited (see footnote 7).
[18] Work cited (see footnote 3).
[19] Work cited (see footnote 6).

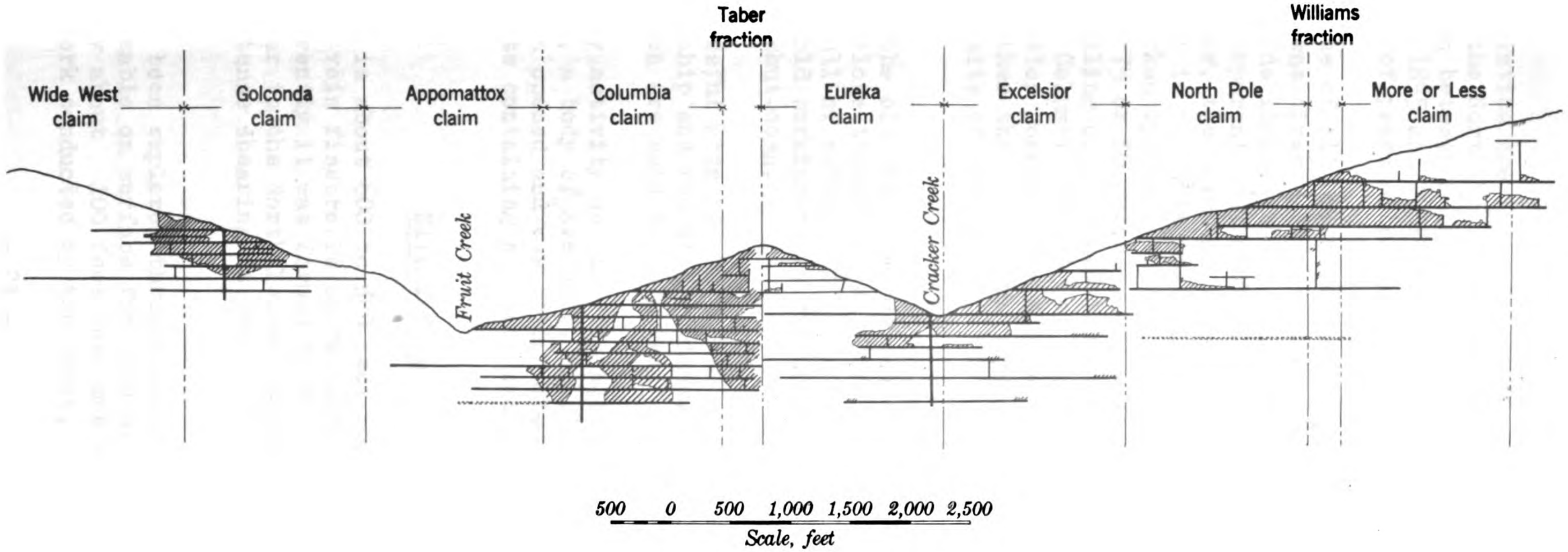

Figure 6.—Longitudinal section through old workings on North Pole-Columbia vein.

Production statistics are incomplete. It is safe to say that the combined production of the North Pole, E. and E., Taber Fraction, Columbia, and Golconda has been between 8 and 8-1/2 million dollars. Most of this was produced between 1895 and 1908; the Columbia, however, continued to operate for a number of years after the others were shut down.

The average value of all ore mined was close to $14 a ton (at $20.67 gold); much of this was direct shipping ore. The value of milling ore varied within such wide limits that a statement of the average would be meaningless. It is apparent that most mills were unable to operate on less than $10 ore. However, the Columbia is said to have operated for some time on $8 mill heads. It is probable that $8 ore represented the lowest grade ore that could be worked by the Columbia at that time. Since mill recoveries were never more than 75 or 80 percent, and were usually much lower, a minimum direct mining and milling cost of about $6 a ton is indicated. It is said that recovery at the Columbia was higher than at other mills in the district owing probably to better general operating efficiency. The question arises, therefore, as to whether the stoped areas shown on the map in figure 6 indicate the actual limits of ore shoots or the limits of economic mining at that time.

Unfortunately, the old workings are not accessible. Within the vein the ground requires close timbering and constant maintenance to keep it open. The old shafts are full of water. It is said, on what is believed to be good authority, that the old workings were making 500 to 600 gallons of water a minute prior to the shut-down.

Several unsuccessful attempts have been made to consolidate all the holdings under one ownership and reopen the mines. Some of the obstacles in the way of a consolidation are said to have been removed recently.

In 1936 the only activity on the vein was at the Golconda. Al Heisler was mining, on lease, a body of ore near the old portal. About 5 feet of shipping ore had been opened and was being mined by hand methods. The ore consisted of argillite containing numerous small veinlets of fine-grained sulphides.

Climax Mine

The Climax vein is about 600 to 800 feet northwest of the Columbia and Golconda mines. The vein fissure is approximately parallel to the North Pole-Columbia fault; apparently it was formed by the same fault movements. The Climax vein is similar to the North Pole-Columbia vein in every respect except size; the zone of intense shearing is from a few feet to ten or twelve feet wide.

The fissure has been explored through adits by several hundred feet of drifting; it is traceable on surface for several claim lengths. An ore shoot about 50 feet long by about 100 feet deep was worked out in the early days. Recent preliminary work conducted by the owner, Grayson Hinckley, has exposed some ore in the bottom of one of the drifts and on surface beyond the face of the underground workings. Preparations were under way to ship ore mined in the course of further exploration.

Ibex Mine

The Ibex and Bald Mountain mines are near the head of McCully Creek, 7 miles from Sumpter. These two mines are on the same fissure and at present are being developed as one mine by the Ibex Gold Mining Co. W. C. Fellows, Baker, Oreg., is vice president and manager; P. S. Anderson is superintendent.

The vein is in a fault fissure in argillite. The strike is N. 25° to 60° E.; dip 60° to 80° southeast. The fissure is said by Lindgren[20] to be traceable for several miles along the outcrop; it has been explored by several thousand feet of underground workings. The sheared zone is from a few feet to 30 feet wide. Quartz veins up to 5 feet wide have been developed on both the Ibex and Bald Mountain properties. The veins that outcrop at about 6,300 feet elevation were developed originally through adit drifts. An ore shoot 600 to 700 feet long was developed in the Ibex mine and another ore shoot several hundred feet long was developed in the Bald Mountain mine. A large mill was built, but production was small; apparently, the cost of operation was greater than the recovered value of the ore. The mill had been dismantled for some years.

In September 1936 the present company had just completed a 1,500-foot crosscut that cut the vein 380 feet below the old workings and about 1,000 feet below the outcrop. The fissure, where cut, was about 30 feet wide; 8 to 10 feet of crushed and highly sheared argillite was said to carry commercial values in gold. A narrow quartz vein within the shear was said to be very low-grade. Reliable information was received later to the effect that drifting on the vein had developed a low-grade ore body 29 feet wide.

Sulphide mineralization is chiefly pyrite and arsenopyrite. Tetrahedrite and marcasite are reported from some parts of the vein; Lindgren mentions that pyrargyrite was found on the outcrop. The ratio of silver to gold is frequently high.

The large mill and some other buildings left by former operators were in good condition. Preparations were under way for the construction of new livin quarters and for the installation of modern equipment in the old mill.

A small, gasoline-driven compressor supplied compressed air for development work. Hand-sharpened chisel bits gave satisfactory service in crosscutting.

The underground crew consisted of 1 miner, 2 muckers, and a blacksmith-general utility man. The crosscut was driven at an over-all direct operating cost of $12.70 a foot.

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[20] Work cited (see footnote 3).

Argonaut Mine

The Argonaut mine is 4.5 miles by road north of the old Columbia mill, at about 700 feet elevation. In 1936 it was being developed by Bascom Parker and associates.

A drift was being driven along a northeasterly striking fissure toward its intersection with an easterly striking fissure, at which point there were good surface showings. The fissures are in argillite a short distance south of the southern edge of the Bald Mountain batholith. About 12 feet of intensely sheared mineralized argillite and gouge was exposed in the face of the drift.

Mountain View Mine

The Mountain View mine is 4 miles by road north of Bourne, at 7,500 feet elevation. It was being operated on lease by L. P. Harmon and C. A. Tibbs.

The vein is in argillite, practically on the contact of the southern edge of the Bald Mountain batholith. The argillite is lighter colored and more fissile than in most mines of the district. The ore consists of veins and disseminations of sulphides, chiefly arsenopyrite, in talcy gouge and silicified argillite.

Between 1904 and 1906 the mine is said to have produced about $100,000 in gold from about 5,000 tons of ore. Two stopes were worked from the adit level about 265 feet to surface. The stopes were either on different fissures or on faulted segments of the same fissure. The vein strikes N. 45° E. and dips steeply to the southeast.

A shaft, now full of water, had been sunk 100 feet on the vein and a drift driven under one of the ore shoots. The ore blocked out was never mined. The present operators had exposed the vein for about 100 feet along the bottom of the adit drift and were preparing to stope by underhand methods. The vein was 3 to 4 feet wide in its widest parts. A car of high-grade ore had been shipped from surface workings.

ROCK CREEK AND ELKHORN DISTRICTS

Although approached by somewhat different routes, the Rock Creek and Elkhorn districts may be considered together. The Baisley-Elkhorn, Maxwell, and Highland mines are on roughly parallel fissures along the southern edge of the Bald Mountain batholith. A number of other veins extend westerly from the Highland mine to the Mountain View mine at the northeasterly end of the Cracker Creek district.

The Baisley-Elkhorn, Highland, and Maxwell have, so far, been the only important producing mines in this district. Together they have produced between 1 and 1-1/2 million dollars in gold and silver. Nearly a million dollars was produced by the Baisley-Elkhorn alone. The district was discovered in the 1880's; it was actively productive in the late 1890's and early in the present century. Since 1914 there had been no important production until the Highland was reopened in 1935. In 1936, exploration work was in progress at the Baisley-Elkhorn, and the Highland-Maxwell group was milling about 50 tons of ore a day.

The veins are on or close to the contact between quartz diorite and argillite. Some are in the diorite, some in the argillite, and others cross the contact. Mineralization is characteristic of the inner zone of Hewett's classification; consequently, the ratio of concentration is low—usually between 5:1 and 10:1. Sulphide mineralization is chiefly pyrite, galena, sphalerite, and chalcopyrite, with some tetrahedrite. The percentage of free gold recoverable by amalgamation is low.

The mines are in the high mountains at the head of Rock Creek and Pine Creek. The two creeks head close together. Most veins are reached via Rock Creek, but the Baisley-Elkhorn is reached only by road up Pine Creek. The principal mine camps are between 6,000 and 6,500 feet above sea level. The veins outcrop at much higher elevations.

The mountains are heavily timbered and water is plentiful. Power lines of the Eastern Oregon Light & Power Co. pass through the district.

Highland and Maxwell Mines

The Highland and Maxwell, although originally two separate mines, have been consolidated and are being developed as one mine by Claire Schlemmer.

This mine is reached from Baker, 12 miles by surfaced highway to Haines, 6 miles by gravel road across Powder River valley, and 7 miles by mountain road up Rock Creek, a total of about 25 miles. In winter, the last 7 miles are impassable to motor transport.

The Highland and Maxwell mines are on a nearly vertical fault fissure in argillite; the strike is N. 70° to 80° E. The ore so far discovered occurs in comparatively small quartz lenses several feet wide. The fissure is strong and persistent; ore bodies have been found at intervals for several thousand feet along the strike. At one place in the Highland, a group of closely spaced lenses might be said to constitute an ore shoot several hundred feet long. Most of the past production of the mine came from this ore shoot above the adit level.

The vein outcrops at much higher elevations in Maxwell ground than it does in Highland ground. When visited, a drift was being driven from the Highland under the Maxwell ore shoots; this drift, although near surface in Highland ground, would gain about 2,000 feet of "backs" in the Maxwell.

Drift rounds 4 to 5 feet deep were broken with 8 holes and about 40 sticks of powder. Drifts were timbered closely but crosscuts were untimbered.

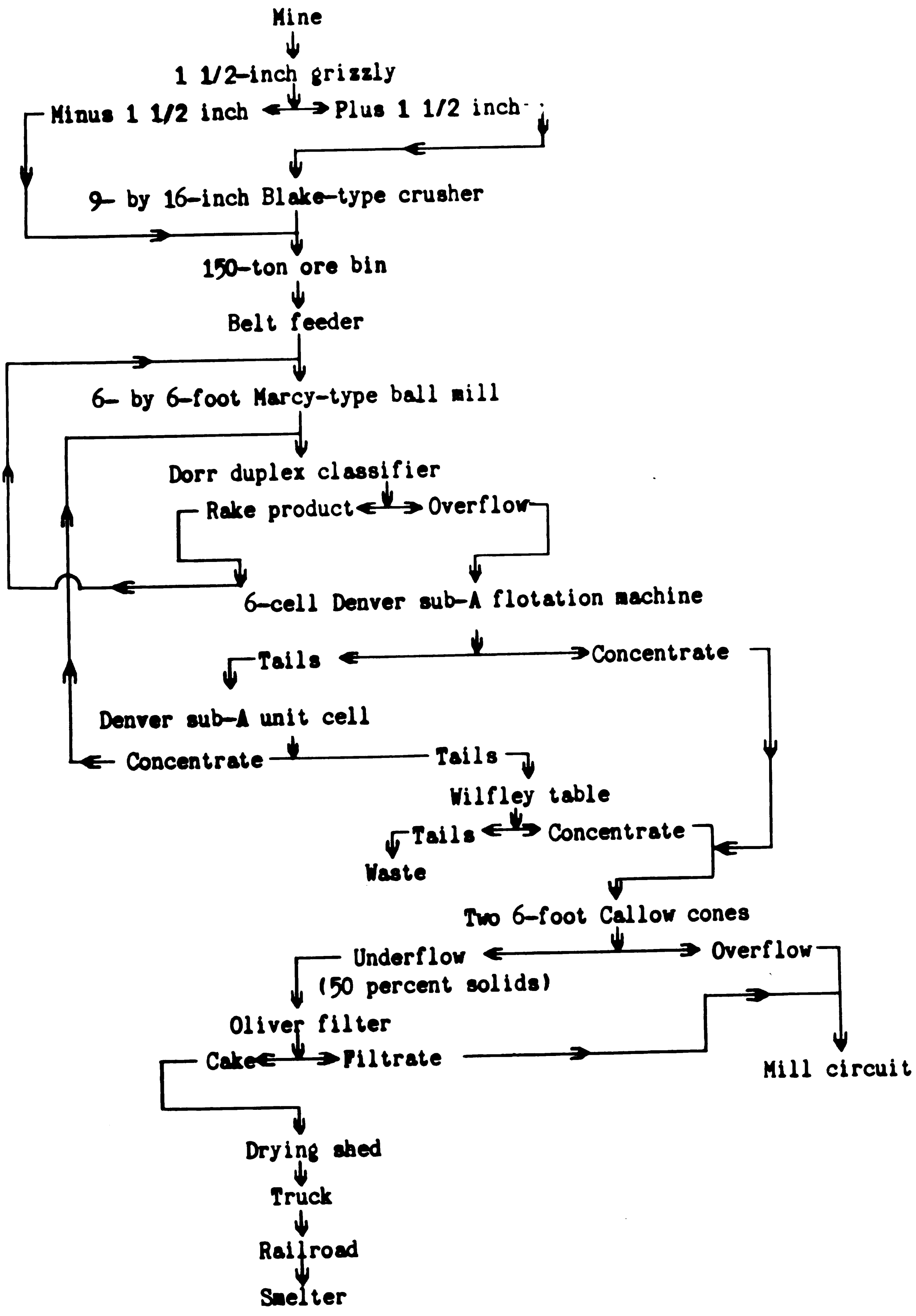

Figure 7.- Flow sheet, Highland mill.

No stoping was in progress; ore for milling was obtained from development and from reserve stocks. The mill flow sheet is shown in figure 7.

The ore is ground to 80 percent minus-60 mesh and treated in a 6-cell Denver Sub-A flotation machine. Feed goes to the first cell; concentrates are taken off the first two cells. Tails from the 6-cell machine are sent to a Denver unit cell, which originally had been used in the ball mill classifier circuit but is now used as a "scavenger." When used in its original position, this cell produced a large amount of froth, which it had been difficult to keep clean; in its present position, the cell aided materially in maintaining a low-grade tailing.

Flotation reagents were:

	Pounds per ton of ore
Pentasol xanthate	0.15
Copper sulphate	.25
Sodium sulphide	.30
Sodium hydrate	.30
Pine oil Coal tar	.2

Extraction was about 95 percent on unoxidized ore but dropped to 60 or 70 percent on highly oxidized ore. Ratio of concentration on unoxidized ore was about 4-1/2 : 1.

Baisley-Elkhorn Mine

The Baisley-Elkhorn mine is near the head of Pine Creek, about 15 miles by road from Baker. The last 4 miles of the road from Baker to the mine is steep mountain grade; the other 11 miles is in the Powder River Valley.

The vein is partly in quartz diorite and partly in argillite. Early operations were chiefly in the diorite. It is said that two ore shoots were worked. One ore shoot was said to have been about 150 feet long, the other 850 feet long. The maximum width of the vein was said to have been about 10 feet, the average width about 2 feet. So far as could be learned, the average value of the run-of-mine ore was between $10 and $20 a ton. Lindgren[21] describes the ore as a "soft mixture of coarse sulphides with crushed diorite and occasional streaks of barren quartz."

Recent operations conducted by the owners have cut the vein several hundred feet northeast of the old workings and about 200 feet below the bottom of the old shaft. A narrow but very persistent vein of highly mineralized quartz has been followed for several hundred feet along intersecting fractures or joints in argillite.

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[21] Work cited (see footnote 3).

VIRTUE DISTRICT

The Virtue district is about 7 miles in a straight line due east of Baker; by road the distance is 9 to 10 miles via the Baker-Richland highway. Most of the mines are on or close to Virtue Flats, a gently rolling area of sand and sagebrush at about 3,500 feet elevation.

The district was discovered in 1862. It has produced about $2,800,000 in gold, over $2,000,000 of which was produced by the Virtue mine.

The Virtue mine was operated from 1871 to 1878 and from 1893 to 1898. According to Lindgren[22], an ore shoot with a maximum strike length of 1,200 feet was mined to a depth of about 1,000 feet below the outcrop. A lean, broken zone was then encountered and operations ceased. The ore was a quartz vein 6 inches to 12 feet wide in a fissure in greenstone. The quartz average about 14 inches wide and from 0.5 to 1.0 ounce of gold per ton. During short periods, values were often considerably higher. The quartz was sparsely mineralized with pyrite and chalcopyrite. Operations at depth were handicapped by a heavy flow of warm water.

In the summer of 1936 the only activity in the district was at the White Swan mine. It was said, however, that recently there had been some activity at the Flagstaff mine.

Although there were no large bodies of developed ore in 1936, the histor of the district and the strength and persistence of some of the fissures suggest the possible existence of strong ore bodies that do not outcrop. Exploration must be through deep shafts and therefore will be costly.

The district is favored by easy, year-round accessibility and by proximity to electric power lines. At present drinking water must be hauled from Baker in barrels, but in many cases water for milling could be pumped from underground workings. There is no timber in the district.

White Swan Mine

The White Swan mine was being reopened and explored by the White Swan Gold Mines, Inc., F. A. Hancock, manager. The mine is reached by automobile via the Baker-Richland highway, 10 miles from Baker, thence by dirt road 5 miles across Virtue flats.

From 1890 to 1897 this mine is said to have produced at least $600,000 in gold from an ore shoot 150 to 300 or 400 feet long and about 334 feet deep In 1916 about $84,000 is said to have been produced from an ore shoot 200 fee long and 100 to 200 feet deep. This ore shoot was about 300 feet east of the old workings. The present company has taken about $30,000 in gold from a downward continuation of the east ore shoot.

The ore occurs in a strong shear zone in argillite. The zone of shearin appears to be several hundred feet wide and contains a number of parallel quartz veins. To date only one of these veins has been an important producer. The ore shoots are quartz veins, averaging several feet wide; they are found at intervals along a line of intense shearing and crushing. The gouge breccia and crushed argillite between the ore shoots frequently carry sufficient gold to be classed as ore. High-grade ore, however, has been found only in the quartz veins. The vein strikes east and dips 70° south.

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[22] Work cited (see footnote 3).

Equipment consists of a well built timber head-frame; single-drum hoist driven by a 175-horsepower motor; a 14- by 10-inch, 14- by 17-inch, 550-cubic-foot compressor driven by a 22-ampere, 2,200-volt motor; pumps; blacksmith shop; and a pilot mill.

A vertical shaft with two 4-1/2- by 5-foot compartments was sunk 350 feet and three stations cut. Connections had been made with the old workings on the west ore shoot, and No.'s 1 and 2 levels were driven eastward under the east ore shoot. No. 3 level had progressed only a short distance east of the shaft.

Shaft sinking cost $13,480 or $38.51 per foot, including timber, pipes, and electric cable. The first 100 feet of sinking had consisted of reopening and enlarging an old prospect shaft; this section had been completed in 20 days. Below the 200-foot level, a heavy flow of water was encountered; which, combined with soft ground, made it necessary to spile the remainder of the distance.

On No.'s 1 and 2 levels the ground was dry. Drifting was contracted at $2.50 a foot for labor. Total cost per foot was

Labor	$2.50
Timber	.70
Explosives, power, and overhead (with two drifts working)	1.80
Total	5.00

On No. 3 level a water flow of 200 to 300 gallons per minute in the soft ground encountered necessitated the use of spiling and breast boards. Work on this level had not been in progress long enough to enable costs to be determined.

Apparently the flow of water was not increasing with depth; upper levels became dry as lower levels were opened.

No stoping was in progress. It was apparent that resuing in the narrower parts of the vein or square-set stoping in the wider parts would be the most suitable mining methods.

Drifts required close timbering, but crosscuts could be left untimbered except in the most intensely sheared areas.

Actual demand power load for mining purposes at full operation was as follows:

	Horsepower
Pumps	60
Compressor	60
Hoist	70
	190

Power consumption varied from 40,000 to 60,000 kilowatt hours per month. The lower figure is for a period in which only one drift was being driven on two shifts.

Power was purchased from the Eastern Oregon Light & Power Co. The White Swan company had constructed 6-1/4 miles of power line across gently rolling desert country at a cost of $847 a mile.

In order to treat such ore as was mined in the course of exploratory work, a small mill suitable for intermittent operation was built. The flow sheet is shown in figure 8.

An extraction of 80 percent was obtained from $10 heads. It is said that tailing assays remain at about $2 per ton when much higher grade ore is treate

Mill capacity is 1.6 tons of semioxidized ore per hour.

KEATING DISTRICT

Until recently the Keating district has been known as a potential copper-mining district. Recent operations by the Balm Creek Gold Mining Co., however have depended more upon the gold content of the ore than upon the copper content.

The district is near the middle of the belt of copper prospects about 15 miles long, extending from a point west of the North Powder River, easterly to the Snake River.

The geology of the district and of the principal ore bodies was described in detail by James Gilluly in 1932[23] and in a private report by Waldemar Lindgren.

The ores of the Keating district occur as disseminations, sulphide veinlets, and replacements along zones of shearing in Permian greenstone. The best ore bodies at Balm Creek are from 3 to 30 feet wide and are found in association with andesite dikes.

Pyrite and chalcopyrite are the only sulphide minerals found in important quantities in the Keating district. Gilluly was of the opinion that the gold

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[23] Gilluly, James, Copper Deposits Near Keating, Oreg. Contributions to Economic Geology: Geol. Survey Bull. 830, 1931-32, Part 1, pp. 1-32.

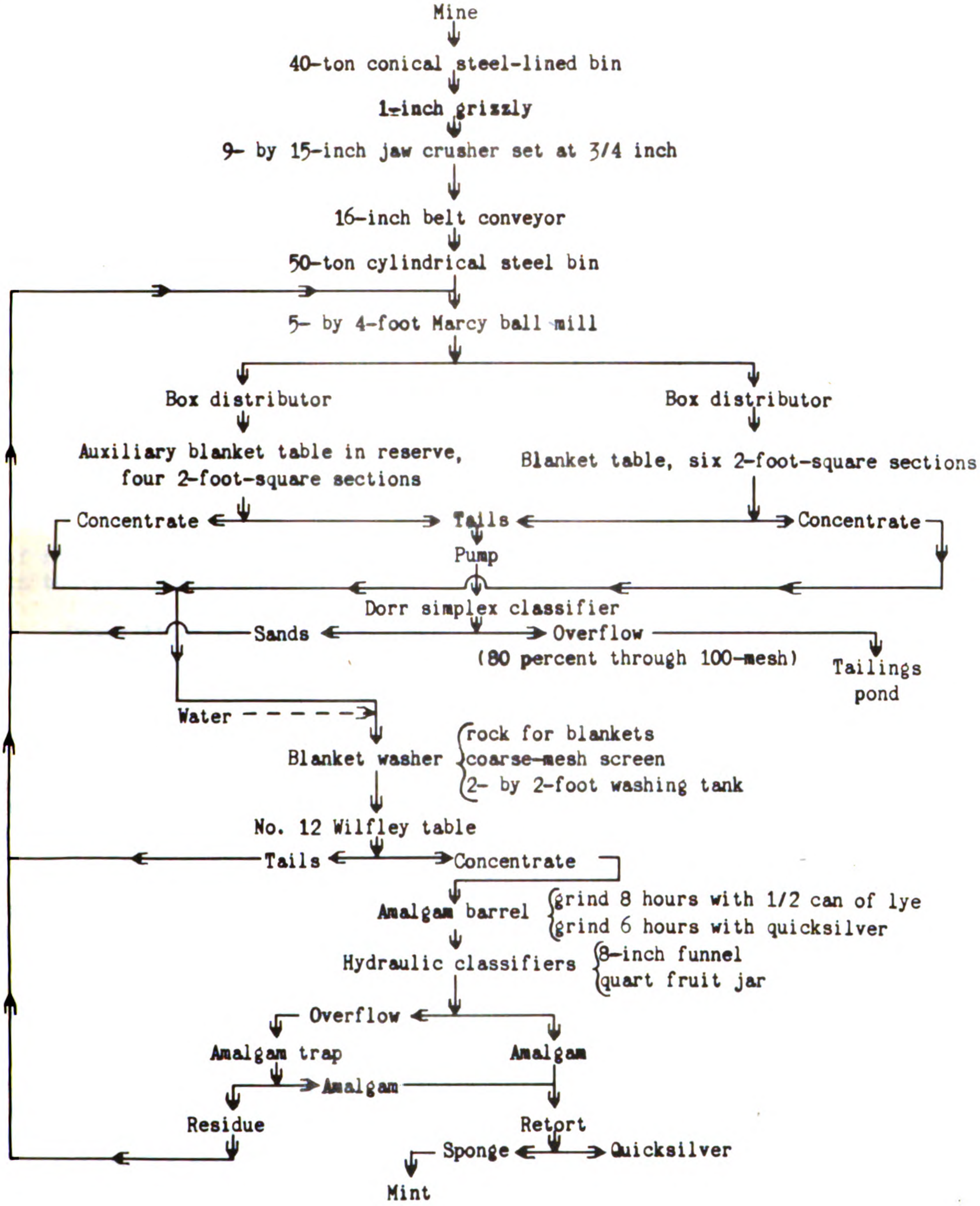

Figure 8.- Flow sheet, White Swan mill.

accompanied the pyrite; John Arthur states that, in the Balm Creek mine, fine free gold has been found in the solid chalcopyrite; he also states that gold values have been higher in the lower levels.

There are several well known copper prospects in the district. So far, only the Balm Creek mine has become an important producer. This mine and the nearby Poorman vein were explored and developed on a large scale by the Oregon Copper Co. in the late 1920's. The Oregon Copper Co. never got into production and, with falling copper prices at the beginning of the depression, finally ceased operations. In 1935 the Balm Creek Gold Mining Co. built a 100-ton mill, which has been operated since the middle of 1935.

During the last half of 1935 the Balm Creek mine produced 13,526 tons of ore, which yielded 2,120 ounces of gold, 1,065 ounces of silver, and 195,179 pounds of copper[24].

The post office at Keating is 17 miles by graveled highway from Baker. The Balm Creek mine is 8 miles by graded dirt road northeast of Keating. No mountain grades are encountered between Baker and the mines.

The Keating district is about 3,500 feet above sea level in a country of rolling hills sparsely covered with sagebrush. There are numerous farms in the nearby valleys.

Power lines of the Eastern Oregon Light & Power Co. pass through the district.

Balm Creek Mine

The Balm Creek mine is operated by the Balm Creek Gold Mining Co., John Arthur, manager. This company is a merger of the Poorman-Mother Lode, Oregon Copper, and Goose Creek properties, with combined holdings of over 100 claims. About 3 miles of underground work has been completed.

When visited, operations were confined to one oreshoot in the Balm Creek mine. This oreshoot, which has been developed from surface to the 450-foot level, is 100 to 170 feet long. About 80 tons of ore was being mined and concentrated per day, and an additional 100 tons per month of crude ore was being shipped directly to the smelter. The direct shipping ore assayed from 1 to 3 ounces of gold and 8 percent copper per ton.

A 700-foot, 2-compartment shaft sunk by the Oregon Copper Co. had been unwatered to the 450-foot level, and work was in progress on this level and on the 150-foot level. A stope up to four sets wide had been worked a few sets above the sill. All stoping is by square-set methods, but work had not progressed far enough to have developed all the details of stoping practice.

Timber is cut and framed in a small saw mill operated by the company.

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[24] Minerals Yearbook, 1936, pp. 326-327.

The flow of underground water varies from 150 gallons per minute in the dry season to 200 gallons per minute in the wet season.

The mill flow sheet is shown in figure 9.

Mine ore is dumped in a 100-ton bin, from which it is hoisted by skip on an inclined tramway to the mill. It is crushed in two stages to 1/2-inch size and ground to 100-mesh in a 6- by 6-foot Marcy type ball mill in closed circuit with a Denver Sub-A unit flotation cell and a Dorr duplex classifier.

Classifier overflow is sent to the first cell of an 8-cell Denver Sub-A flotation machine, which produces a final tail, and a finished concentrate. Concentrates are taken off the first three cells.

Acid mine water is used in the flotation circuit. About 0.22 to 0.26 pound of potassium xanthate was used per ton of ore. In addition to the xanthate, a mixture in the proportions of 10 percent tar oil, 40 percent acid creosote, and 50 percent pine oil was fed at the rate of 25 to 40 drops a minute.

Flotation tails are sent direct to the settling pond. Occasionally, about 25 pounds of lime per shift are added to the tails to promote settling.

Fine concentrates are thickened and then filtered in an Oliver filter. Coarse concentrates from the unit cell are separated and dewatered in a drag classifier before filtering. The filter cake is dried to 4 to 6 percent moisture in a Lowden drier. The drier burns scrap from the saw mill and, in addition, about 15 cords of wood per month. Firewood costs $4.50 per cord

Total extraction is 85 to 90 percent on sulphide ore and about 75 percen on partly oxidized ore. About 20 to 30 percent extraction is made in the uni cell. The ratio of concentration is 7-1/2:1.

The mill is operated with two operators per shift and one crusher man and one foreman-assayer on day shift.

During the first winter's operation, 80 cords of wood were required to heat the mill from October to the middle of April.

Power for drilling and hoisting is supplied by a 625-cubic-foot Sullivan compressor driven by a 120-horsepower Fairbanks Morse Diesel engine. The Diesel consumes a little over 3 gallons of fuel oil per hour of operating time. The compressor is also connected to electric power, which may be used if desired.

Power for milling and other purposes is purchased from the Eastern Oregon Light & Power Co. The total connected electric power is 515-horsepowe The actual demand load is 261 kw., or 350 horsepower.

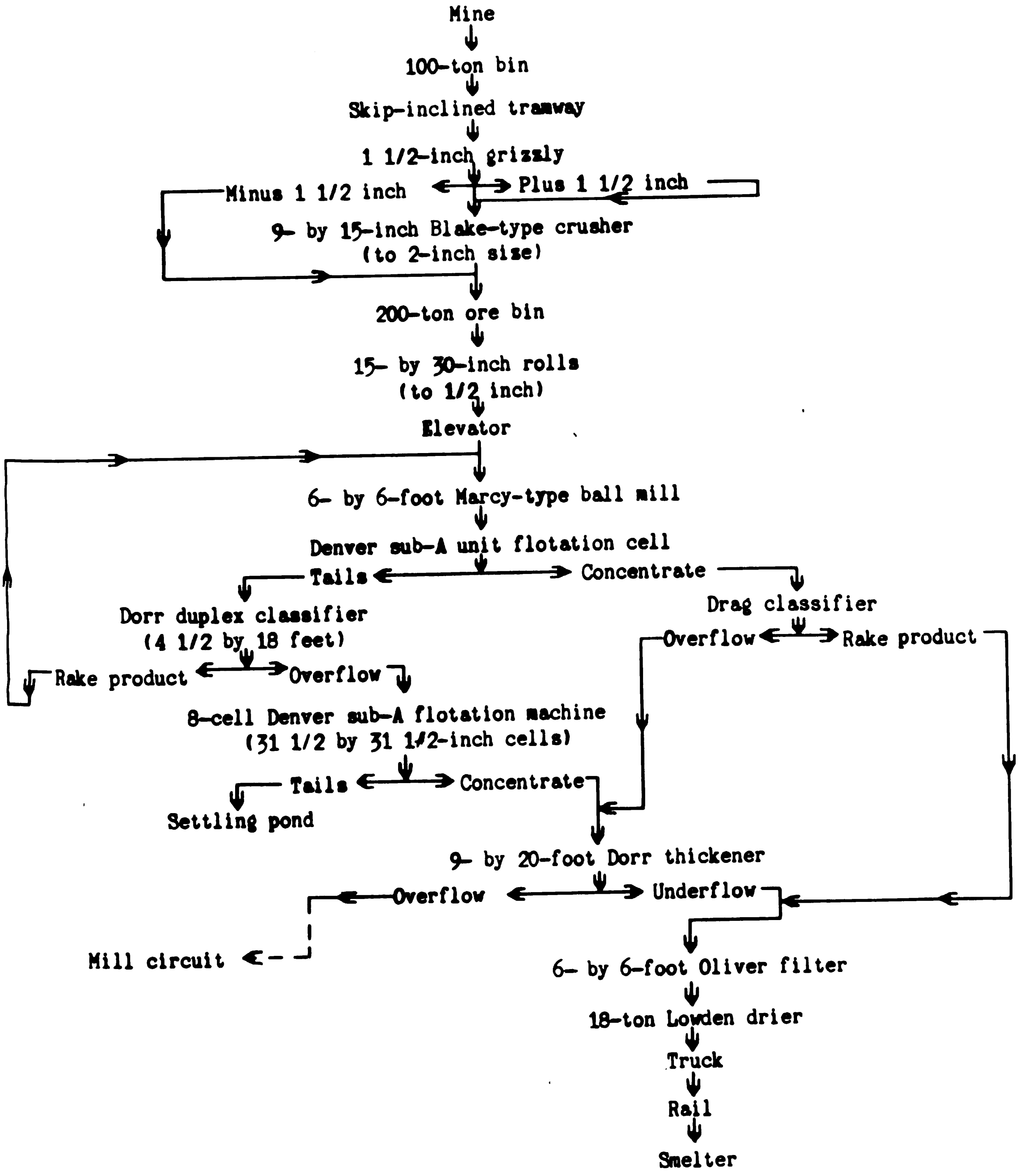

Figure 9.- Flow sheet, Balm Creek mill.

MEDICAL SPRINGS DISTRICT

The town of Medical Springs is about 25 miles from Baker at 3,350 feet elevation. In the Medical Springs district only one property, the Twin Baby, has been developed to the producing stage.

Most of the district is covered with geologically recent volcanic flows. The Twin Baby mine is in a small area of ancient (probably late Paleozoic) volcanics, which have been exposed by erosion. Even within this small area, prospecting is rendered difficult by the heavy mantle of soil.

Development is still in the prospect stage. The Twin Baby vein fissure, however, is strong and well defined; the quartz veins, though short in lateral extent, are strong and fairly uniform in value. The future of the district obviously depends upon enlargement of the oreshoots with depth.

Transportation conditions are very favorable. Timber is locally abundant. Water for milling is scarce - it will have to be pumped from mine workings.

Twin Baby Mine

The Twin Baby mine was being operated by the Vindicator Gold Mines Co., P. C. Murphy, manager. The mine is 2.5 miles by good mountain road from Medical Springs, at 4,300 feet elevation. The nearest available shipping point for carload lots is at the Pondosa lumber mills, 3.2 miles distant. When the mine was visited concentrates were being trucked 27 miles to Baker.

Two ore shoots 50 feet apart, each about 70 feet long, had been developed. The ore shoots are quartz veins 1 to 4 feet wide in a strong, well defined fissure in "greenstone." The greenstone apparently is a volcanic extrusive. The fissure is about 4 feet wide; where barren, it is filled with fault breccia and usually contains a strong seam of gouge, which carries low gold values. The fracture strikes north, and dips 80° east. It has been explored for a strike distance of 600 feet.

The mine was equipped with a 620-cubic-foot air compressor, which supplied air for drilling, hoisting, and pumping; a 40-ton amalgamation-flotation mill, shops, cookhouse, and cabins for employees.

A vertical shaft had been sunk 335 feet on the vein. Drifting was in progress from the 335-foot level and apparently had just picked up the downward continuation of the oreshoot. The 230-foot level had been driven north and south a total distance of about 600 feet on the vein; most production was coming from this level.

An underground crew of four men was producing 12 tons of ore per day (one shift) from a short stope and raise on the 230-foot level. Stoping was by resuing. Drifts and raises were closely but not heavily timbered.

The mine was making 12 gallons of water per minute.

Figure 10 is a flow sheet of the Twin Baby mill.

When visited, the mill was operating on a one-shift basis, milling 12 tons of semioxidized ore per day. Ore was crushed to 80 mesh; about 30 percent of the values were recovered on the amalgam plate. Pulp feed to the plate was distributed by an ordinary box distributor mounted, separately from the plates, on flexible supports. A rod from the distributor to an eccentric attached to a jackshaft imparted a longitudinal shaking motion to the distributor. This prevented any banking of pulp in the distributor box and insured an even flow of pulp to the plates.

Flotation reagents consisted of 0.38 pound of amyl xanthate per ton of ore and a mixture of one part acid creosote, one part pine oil, and one-fourth part aerofloat. This mixture was fed at the rate of 60 drops per minute. Two pounds of soda ash and one-fourth pound lime per ton of ore were added to the ball-mill feed.

Mill heads averaged about $10 per ton and a $250 concentrate was produced. Allowing for recovery by amalgamation, this indicated a ratio of concentration of about 40 to 1.

Power for mining was supplied by a 120-horsepower Diesel engine. The mill was driven by an old type 75-horsepower semi-Diesel. Both engines were usually operating at full capacity; each was said to consume about 5 gallons of fuel oil per 8-hour shift.

SANGER DISTRICT

The Sanger district is about 12 miles by road southeast of Medical Springs. Although practically inactive for many years, the Sanger mine is estimated to have produced about $1,500,000 from a quartz vein in argillite prior to 1900. According to Lindgren[25], the oreshoot in the upper stopes was 600 feet long, about 15 inches wide, and averaged $20 to $25 a ton in gold; below the zone of oxidation the vein widened to 3 or 4 feet and the value dropped to $12 a ton. The sulphide mineralization was chiefly pyrite, chalcopyrite, and sphalerite.

SPARTA DISTRICT

The mines of the Sparta district are on a rolling plateau in the vicinit of the small settlement of Sparta. The town is reached by automobile from Baker, 27.6 miles via the Baker-Richland highway, thence 8.2 miles by a fairl good dirt road that climbs from the highway in Powder River Valley (at about 2,500 feet elevation to Sparta) at 4,200 feet elevation.

Timber near the mines is sufficient to supply the needs of small operations. Sawed lumber may be obtained from small mills on Eagle Creek, 10 mile distant.

Water for milling is scarce. In most cases it must be obtained from underground operations.

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[25] Work cited (see footnote 3).

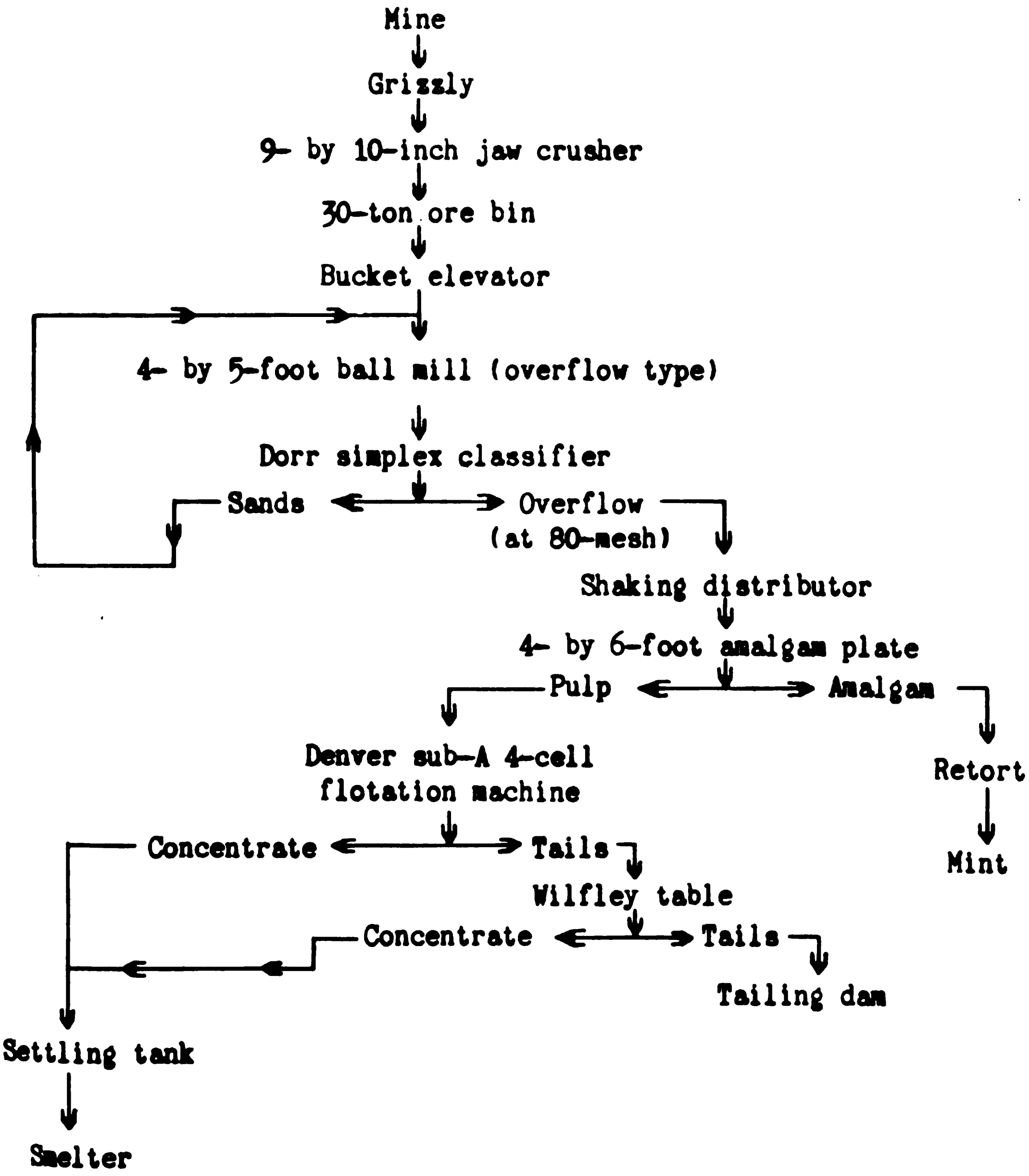

Figure 10.- Flow sheet, Twin Baby mill.

In the early days some production was obtained from placers; this led to the discovery of the quartz veins. The greatest activity in lode mining was prior to 1900; consequently, production figures are incomplete. Lindgren[26] lists 10 mines that between 1889 and 1892 had a combined production of $677,000 in gold. None of these mines were worked to a depth of more than 100 or 200 feet.

Until recently, the district had been inactive for many years except for spasmodic developments. In the summer of 1936, the Gem mine was milling 25 to 30 tons per day and the New Deal mine was being developed.

Oreshoots so far developed have been small. Many stringers of high-grade ore have been mined, but the average tenor of milling ore appears to be of medium grade. Operating conditions for small-tonnage mining are favorable, it should be possible to obtain fairly low production costs. The success of future operations will depend largely upon the amount of development required per ton of ore developed.

Gem of Sparta Mine

The Gem of Sparta mine probably is the best known operation in the Sparta district. It is about 2 miles west of the Sparta post office and about 1/2 mile south of the Sparta-Baker road. The mine was being operated by the Gem of Sparta Gold Mining Co., C. J. Pickarts, manager.

The ore occurs in quartz stringers and lenses, with gouge and brecciated granite, between granite walls 1 to 8 feet apart. Within the oreshoots is some dissemination of sulphides through the gouge and breccia. The principal oreshoot being worked was about 50 feet long and 4 or 5 feet wide. Narrower widths of ore were exposed at several other points along a strike length of about 250 feet.

The vein strikes north and dips 40° east. Mineralization is chiefly pyrite and arsenopyrite, with some chalcopyrite and other sulphides. Some high-grade ore occurs in the narrower stringers. The vein matter between walls was said to average about $10 a ton in the oreshoots.

The mine was equipped with an 18- by 16-, 11- by 16-inch two-stage compressor that supplied air for hoisting, pumping, and drilling; a single-drum air hoist; mining equipment; shops; bunkhouse; and 40-ton amalgamation-flotation mill.

A small, 2-compartment shaft had been sunk 550 feet. Of this distance, 185 feet was vertical and 365 feet on the dip of the vein. Old workings extended along the vein from the bottom of the vertical shaft to surface. Levels had been driven at regular intervals from the inclined section of the shaft. Current production is coming from the lowest levels.

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[26] Work cited (see footnote 3).

Stoping was by open, overhand methods. The ground was supported by irregularly spaced stulls. Broken ore was scraped by hand methods down plank slides to the drifts. Two muckers were required for each miner.

About 20 to 25 gallons of water per minute was being pumped.

Figure 11 is the flow sheet of the Gem of Sparta mill. Mill capacity was 1-3/4 tons of semioxidized ore per hour. Inasmuch as tails were not being thickened, the supply of mine water permitted mill operation on a two-shift basis only.

Flotation reagents were pentasol xanthate, 0.15 pound per ton, and pine oil, variable.

A 92-percent recovery was attained. On highly oxidized ore, 50 percent of the total recovery was obtained on the amalgam plates.

Concentrates assayed $150 to $200 per ton.

Power for mining was supplied by a 175-horsepower Diesel engine; fuel consumption was 6 gallons of fuel oil per hour.

The mill was driven by a 75-horsepower Diesel, consuming 3 gallons fuel oil per hour. This engine also drove a 25-kw. generator, which supplied electricity for lights and miscellaneous needs.

New Deal Mine

Within sight of the Sparta postoffice, the New Deal Mining Co., L. E. Boyer, manager, was developing a vein not hitherto developed except by shallow surface workings.

A single-compartment winze had been sunk 140 feet on the dip of the vein and drifts were driven 60 feet each way on the 100-foot level.

The ore consists of quartz lenses and stringers, with gouge and granite breccia, between granite walls about 4 feet apart. The quartz varies from a few inches to four feet wide; it has been continuous in varying widths and values for the depth of the shaft. Assays were said to have averaged $20 a ton in gold. The vein strikes N. 30° W. and dips 40° east.

Northwest of the shaft the vein is broken up by cross-fracturing. About 200 feet southeast is an old prospect shaft with good ore on the dump. Several hundred feet farther southeast, on the strike of the vein, are the strong quartz outcrops of "Gold Ridge." These outcrops are nearly continuous for several hundred feet. Between 1889 and 1892 a recorded production of $124,000 was obtained from surface workings on Gold Ridge.

The mine was equipped with a small gasoline-driven hoist, compressor, mining equipment, and a boarding house. A bunkhouse was in course of construction.

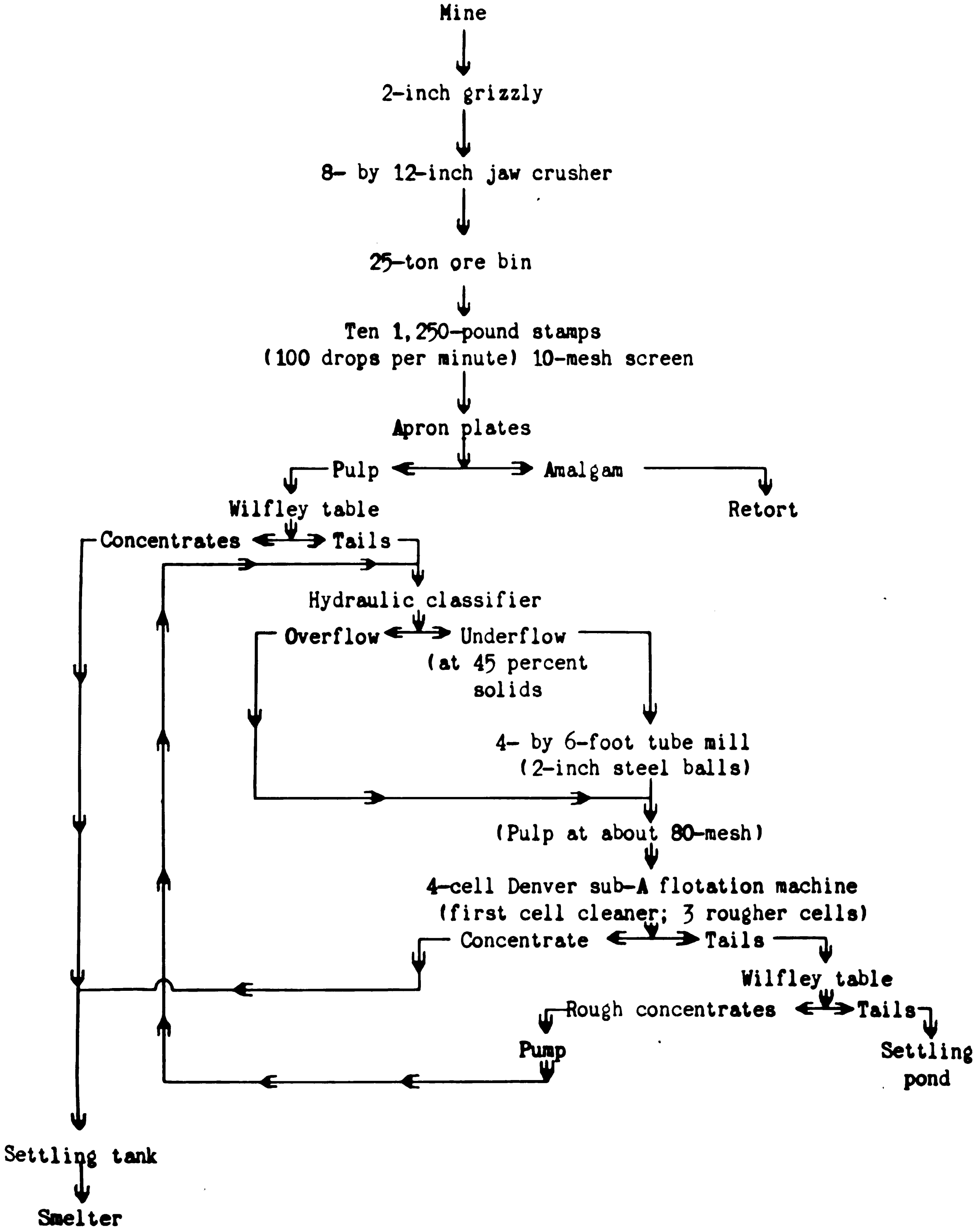

Figure 11.- Flow sheet, Gem of Sparta mill.

The winze was said to have been sunk at an over-all cost of $10 a foot. No appreciable water had yet been encountered.

CHICKEN CREEK DISTRICT

Although the Chicken Creek district is noted chiefly for the old placer workings on Sisley and Chicken Creeks, a considerable amount of lode gold has been produced from small mines near the head of the placer workings.

The ore is in quartz veins occupying fractures in a large granitic stock. The veins so far developed have been small but high-grade. The gold usually is free; oxidation of the sulphides is nearly complete at the lowest levels mined.

The Gleason, Little Hill, Halleck, Gold Cliff, and Gifford and Johnson veins were being or had recently been worked on a small scale. The first three of these veins were within a few thousand feet of each other and were roughly parallel. Another parallel vein, known as the Bonanza, was said to have produced $150,000 to $200,000 in the early days from an oreshoot 300 feet long and about 200 feet deep. The workings are now caved.

The district is reached from Baker, 36.4 miles via the Baker-Huntington highway, thence 4 miles up Chicken Creek by an ungraded but not excessively steep dirt road. This road climbs from the Burnt River, at about 2,500 feet elevation, to an elevation of 4,000 to 4,500 feet at the mines.

In the immediate vicinity of the mines the country is nearly devoid of timber, but there are good stands of fir and tamarack within 3 miles. Water is scarce, but sufficient flows in the creek bottoms to supply drinking water and water for very small-scale milling operations. Sisley and Chicken Creeks, however, are connected by an old ditch dug by the placer miners; it is said that the flood waters of these two creeks could be impounded in a single reservoir.

The nearest railway connections are at Weatherby, 5-1/2 miles distant, or at Lime, 9 miles distant. These are not regular shipping points but probably could be used by special arrangement.

Gleason Mine

The most extensive underground workings in the district are at the Gleason mine, owned and operated by A. V. Lovejoy.

An oreshoot about 300 feet long and averaging perhaps 3 feet wide in the upper workings has been mined about 200 feet on the dip of the vein. In the lower workings so far opened the shoot is about 100 feet long and averages 12 to 18 inches wide. The vein strikes N. 15° W.; dips 80° westerly in the upper workings, but flattens to about 50° in the lower workings. The oreshoot appears to have a strong rake to the south. Exploration has not been pushed beyond faults that cut the vein on both the north and south ends of the oreshoot.

The vein has become higher-grade but narrower with depth. The ore milled from the lower workings is said to have averaged 1 to 1-1/2 ounces of gold per ton. The grade was said to have been considerably lower in the upper workings.

Equipment consists of a small gasoline-driven hoist, a small pump driven by a pump jack from a small kerosene engine, and the necessary mining and blacksmith tools. There is also a 5-stamp mill driven by a 12-horsepower steam engine. Steam is generated in a 14-horsepower wood-burning boiler.

Mining is by hand methods. The ore is so completely oxidized that usually it may be drilled with augers. However, the granite walls are strong and require little support. Very little water has been encountered.

The upper workings were mined through an adit from the north side of the ridge. Present work is through a 900-foot crosscut from the south side of the ridge. This crosscut taps the vein 85 feet below the upper tunnel. From the lower adit level, a winze has been sunk 100 feet on the vein.

Mine ore is fed directly to a battery of five 650-pound stamps, from which it passes through a 45-mesh screen over an amalgam plate and thence to waste.

It is said that 90-percent recovery is obtained from $40 heads.

Gifford-Johnson Mine

The gold Cluster group of claims, owned and operated by Gifford and Johnson, is about 2 miles west of the Gleason mine and about 4 miles by road from the main highway.

This mine was not visited. However, it was producing steadily on a small scale from a high-grade quartz vein said to average 2 to 12 inches wide. The ore was milled in a 5-stamp mill in which a high recovery was obtained by straight amalgamation.

A communication from Mr. Gifford states that the vein on which work is progressing is developed by an upper tunnel 100 feet long, a middle tunnel 100 feet long, and a lower tunnel 200 feet long; the lower tunnel cuts the vein 200 feet below the outcrop. Gifford states further that the gold produced assays over 800 fine and the ratio of silver to gold is about 1:1.

MORMON BASIN DISTRICT

The Mormon Basin district is on the border between Malheur County and Baker County, about 22 miles southwest of Durkee and 25 miles northwest of Huntington.

The district is chiefly notable for the Rainbow mine, which, from 1911 to about 1914, produced $1,083,000 from 95,747 tons of ore. During this time the mine was operated by the United States Smelting, Refining, and Mining Co.; earlier production is said to have amounted to about $200,000. According to Swartley[27], the oreshoot was a fracture zone from a few feet to 50 feet wide, in slate with granitic intrusives, limestone, and greenstone.

There are a number of other veins in the district, most of which have been described recently by Gilluly, Reed, and Park[28].

CONNOR CREEK DISTRICT

The Connor Creek mine, which has been the only important producer of the Connor Creek district, is on Connor Creek about 2-1/2 miles above the Snake River at an elevation of a little over 3,000 feet; the surrounding mountains are high and rugged. The nearest railroad point is at Home, Oreg., 3 miles by road from the mine.

Various estimates of the total production of the Connor Creek mine have been made; the most probable estimate places production at about $2,000,000. The oreshoot, which was a quartz vein in argillite and greenstone, had a maximum length of about 1,400 feet and was mined to a depth of about 1,000 feet below the outcrop; it averaged 1-1/2 to 4 feet wide. Mineralization was chiefly free gold with pyrite and some argentite.

CORNUCOPIA DISTRICT

The quartz veins of the Cornucopia district are in the high, precipitous mountains north and northwest of the small town of Cornucopia. The district is reached from Baker, 65 miles by graveled highway to the town of Halfway, at an elevation of 2,600 feet, thence 10 miles by dirt road up Pine Creek Valley to Cornucopia at an elevation of 4,700 feet. The veins outcrop along the mountain sides at elevations of 6,000 to 8,000 feet. A recently completed 6,200-foot crosscut from Pine Creek valley has developed strong ore bodies on the Union vein at 4,800-foot elevation.

The only important lode-gold production of the district has come from veins of the Cornucopia mines. These have produced about $12,000,000 in gold and silver, approximately $9,000,000 of which came from the Union vein. The Union vein outcrops at about 6,100 feet elevation; three other important parallel veins of the Cornucopia group - the Last Chance, Wallingford, and Mountain View - outcrop at successively higher elevations. Of these, the Last Chance has been the largest producer. There are other veins in the Cornucopia group and some on other claim groups in the district; none of these were active in 1936.

Several small or medium-sized placer operations were active on Pine Creek between Cornucopia and Halfway.

The quartz veins are in or near a granitic stock intruded into micaceous schists. The schists, locally called "greenstone", were believed by Lindgren to be metamorphosed Triassic sediments and lavas. Thick beds of the Columbia River lavas (Neocene) overlie much of the district. Basaltic dikes, contemporaneous with the Neocene lavas, cut the ore deposits and, in places, follow the same fractures occupied by the quartz veins.

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[27] Work cited (see footnote 5).

[28] Work cited (see footnote 7).

Many of the veins are remarkably strong and persistent; the main oreshoot in the Union vein has been mined almost continuously for 700 to 1,200 feet along the strike and over 1,000 feet on the dip of the vein; its downward continuation for at least several hundred feet has been proved by the recently completed crosscut.

Operations in the past have been rendered difficult and expensive by the fact that the veins outcrop high up on the sides of precipitous mountains. Transportation, both underground and on surface, has always been a difficult problem. The crosscut to the Union vein was designed partly to solve this problem.

The district is well timbered where the mountains are not too precipitous Water is abundant for all purposes; hydroelectric power is available during part of the year.

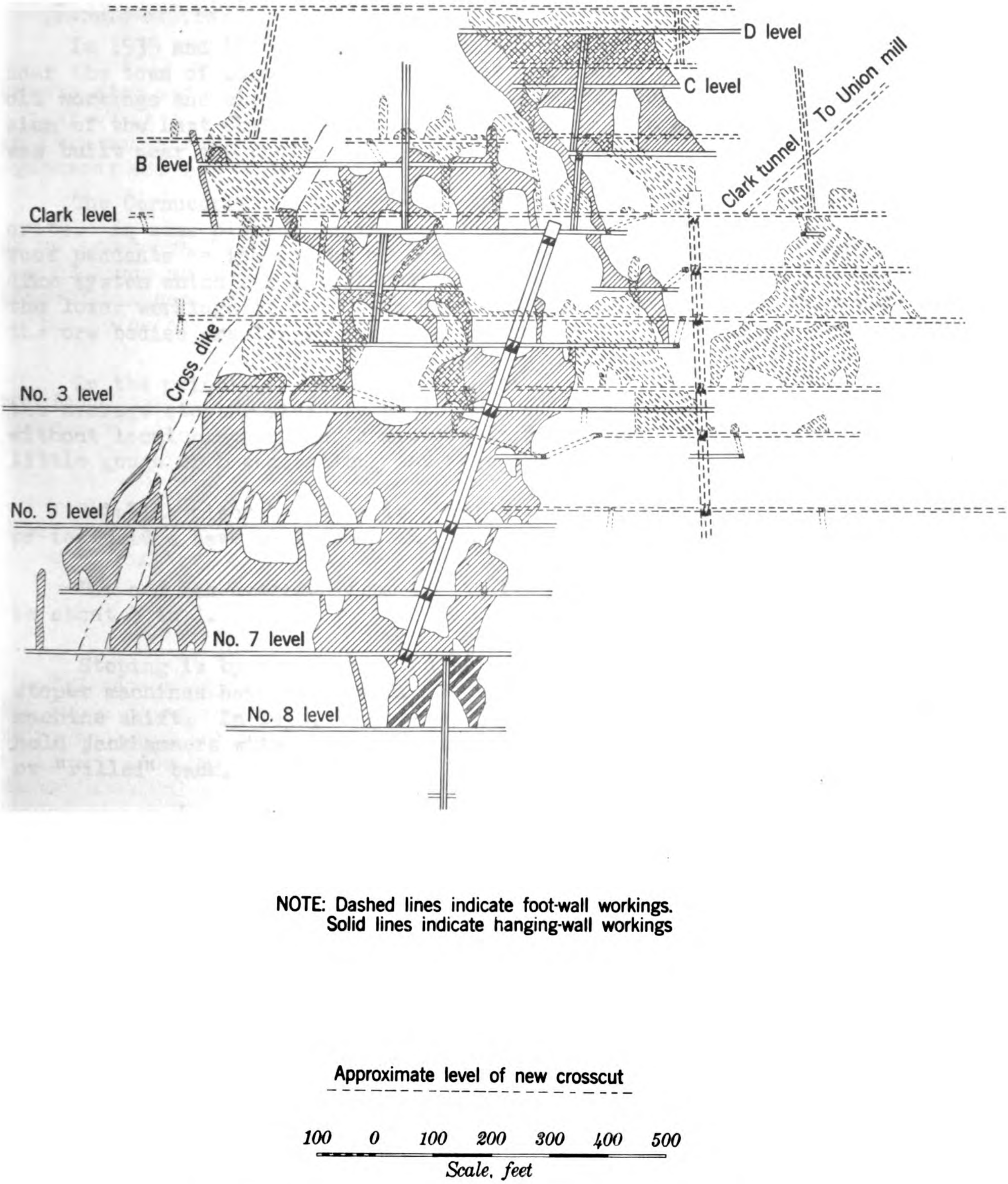
The nearest shipping point is at Robinette on the Snake River at an elevation of 1,878 feet and 15 miles by graveled highway from Halfway. In winter, the highway to Halfway is kept open for automobile traffic; from Halfway to the mines, winter travel is by horse or tractor-drawn sleds.

Cornucopia Mine

Figure 12 is a longitudinal section through old workings on the Union vein at the Cornucopia mine. The mine was brought into production about 1888, eight years after the discovery of the district. By 1900 the mine had produce about $600,000 in gold and silver. Although subjected to numerous changes of management and several shut-downs, it has continued to be an important produce to the present. Operations have been conducted on several veins, but production has come chiefly from the Union or Union-Companion and, to a lesser extent, from the Last Chance vein.

Until recently the main camp and mill were several miles from the town of Cornucopia, near the head of Fall Creek. Another mill, in Pine Creek Valley above the town of Cornucopia, was operated for a number of years on or from the Last Chance and other veins. Ore was brought to this mill by aerial tramway.

The Union vein originally was mined through an adit crosscut from the main camp. Most of the Union oreshoot was below the adit level. Shafts were sunk and the oreshoot stoped to the seventh level. About 1920, costs had become too high and work on the Union vein was discontinued. Underground connections were then made with the Last Chance mine and the ore was treated in the Union mill. Finally, the scattered nature of the workings and increasing costs for labor and supplies brought about a cessation of operations.



NOTE: Dashed lines indicate foot-wall workings.
Solid lines indicate hanging-wall workings

Figure 12.—Longitudinal section through old workings on Union vein, Cornucopia mine.

A few years ago the property was reopened by the Cornucopia Gold Mines, the present operators. R. J. Cole is resident manager.

In 1935 and 1936, a 6200-foot crosscut was driven from Pine Creek Valley near the town of Cornucopia. This crosscut opened the Union vein below the old workings and ultimately may be continued to prospect the downward extension of the Last Chance and other veins. In 1936 a 250-ton flotation mill was built near the portal of the crosscut.

The Cornucopia ore bodies are strong quartz veins, chiefly in granodiorite. In some places, particularly in the upper levels, the veins are in roof pendants or inclusions of greenstone; they are associated with a complex dike system which has interfered to some extent with mining operations. In the lower workings of the Union vein the dikes have diverged from the vein and the ore bodies are larger and more continuous but of somewhat lower grade.

In the principal oreshoots, vein widths of 6 to 8 feet are not uncommon; the average stoping width is probably 4 or 5 feet. Vein widths are maintained without local pinching for considerable distances. There is comparatively little gouge or breccia along the vein fractures.

Sulphide mineralization is chiefly chalcopyrite and pyrite. Rich pockets of tellurides have been found in places.

The ore has averaged from $10 to $20 a ton. The ratio of silver to gold is about 5 to 1.

Stoping is by open, overhand methods, with stull support. In the past, stoper machines have been used. Seven or eight 5-foot holes were drilled per machine shift. In 1936, the stoper machines were being replaced by hand-held jackhammers with which it was planned to drill down holes in an inclined or "rilled" back.

Stulls were about 8 inches in diameter, usually placed irregularly at about 10-foot intervals where the walls were granodiorite. In greenstone, or next to dikes, a wider spacing could be used.

In 1936, operating conditions were changing so rapidly that current operating data would have little meaning. Mining efficiency under the old conditions is indicated by the following record of unit production from the Last Chance mine in 1923[29].

	Tons per man hour	Man hours per ton
Miners in stopes	2.118	0.472
Miners developing in ore	1.663	.601
Miners developing in waste	1.642	.609
All miners	1.994	.501
All underground labor	.4256	2.349

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[29] Betts, Robert M., Mining methods at Cornucopia, Oreg.: Trans. Am. Inst. Min. and Met. Eng., vol. 72, 1925, p. 155.

Labor cost was 53 percent of total direct mining cost.

These figures are based on a production of 9,014 tons in three months.

It is apparent from the above that between three and four times as much labor was required for tramming, mucking, hoisting, etc., as was required for breaking rock.

The history of milling at Cornucopia roughly has paralleled the development of gold metallurgy throughout the world. The first mill is said to have been an ill-advised attempt at pan amalgamation. This was followed by a chlorination plant, which, in turn, was abandoned for direct shipping. An amalgamating, concentrating plant was then built, to be followed, about 1912, by a cyanide plant. For some years two mills using the cyanide process were operated.

The present operators converted the old Union cyanide plant into a flotation mill. This was soon to be superseded by a new and modern flotation mill on Pine Creek.

When visited in 1936, the Union mill was treating 70 to 100 tons of ore per day. Mine ore was passed through a 2-inch grizzly to a 150-ton bin and thence to a battery of twenty 1,050-pound stamps. Stamp product passed through 8-mesh screens to a 5- by 7-foot ball mill, operating in closed circuit with a Denver unit flotation cell and a Dorr classifier.

Classifier overflow, at 80 percent minus 65 mesh, was treated in a 4-cell Fagergren flotation machine. Froth from the first two cells went to a 1-cell Fagergren cleaner. Froth from the cleaner cell and from the unit cell went to a leaf filter, thence to the smelter. Tails from the cleaner cell returned to the classifier.

Flotation reagents were potassium ethyl xanthate and pine oil.

Recovery was 94 percent and ratio of concentration 30 to 1.

Power was supplied by the company's own hydroelectric plant. This had a capacity of 700 kw. in the summer and about 200 kw. in the winter. Plans had been made for the installation of a Diesel plant for winter use.

BULL RUN DISTRICT

The Bull Run district is 6 to 9 miles southwest of the town of Unity in a comparatively low mountain range known as the Bull Run mountains. Although this is one of the newer and less well known districts, three mines have been brought to the producing stage.

The developed mines are a short distance northeast of an intrusive mass of granodiorite, which forms the backbone of the Bull Run mountains. The ore bodies vary considerably in type and mineralization; none were of the simple quartz-vein type so common in eastern Oregon. In one mine the gold was said to have been chiefly associated with arsenopyrite, but in another chalcopyrite was the principal gold-bearing sulphide. Most of the ore mined has been highly oxidized and contains a high percentage of free gold.

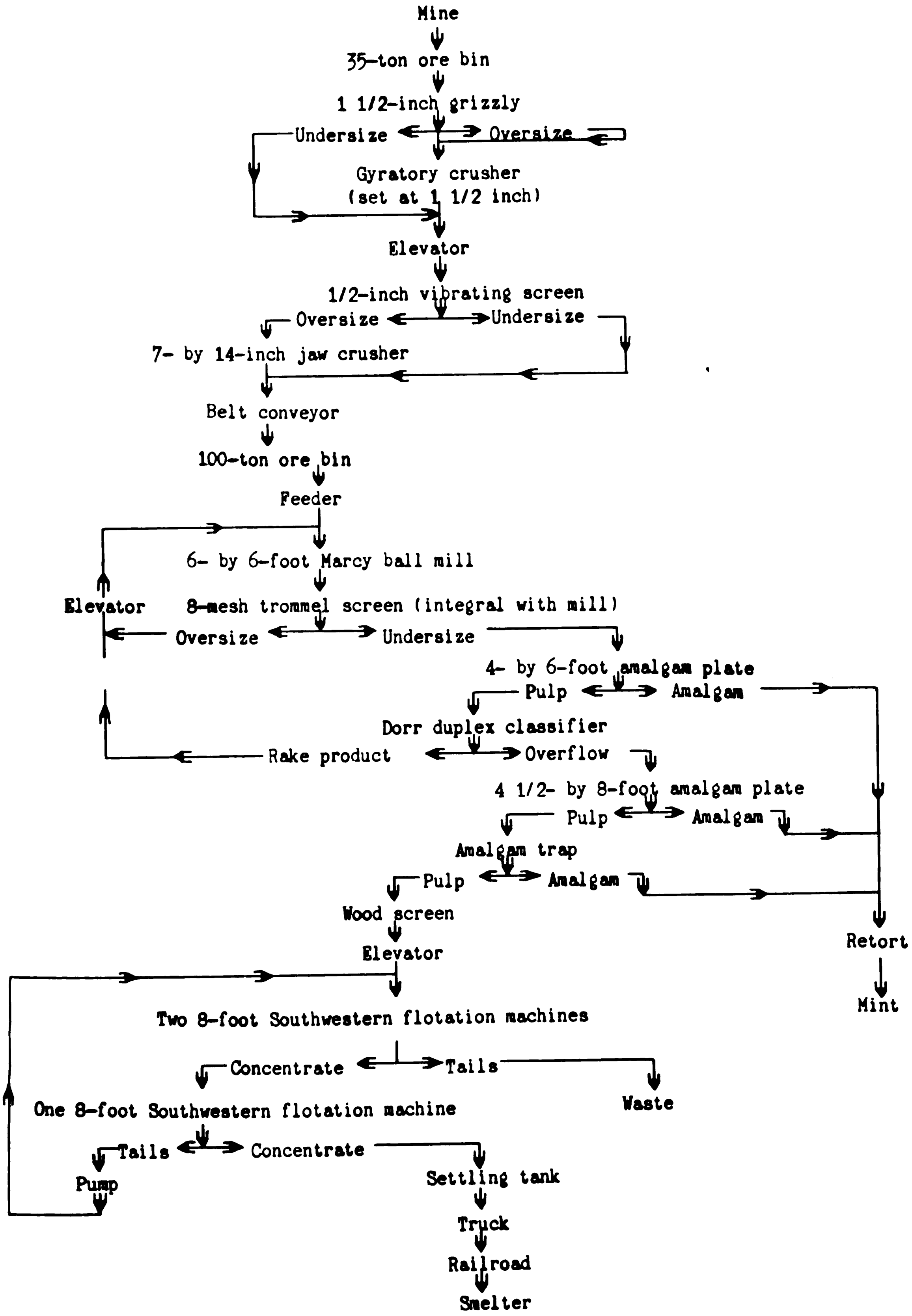

Figure 13.- Flow sheet, Record mill.

The district is easily accessible from Unity over fairly good dirt roads and easy grades. An abundance of good timber and ample water for small operations exist. However, there is a 50-mile truck haul from Unity to Baker; the road passes over a 5,400-foot summit but is a main graveled highway suitable for year-round hauling.

Record Mine

The Record mine is operated by the Record Gold Mining Co., W. C. Fellows, manager.

The principal oreshoot is composed of a number of closely spaced parallel stringers of high-grade quartz in altered and slightly mineralized felsite porphyry. Taken together, the veins and the intervening porphyry constitute a vertical lode 5 to 10 feet wide. The lode strikes about N. 60° E. A short distance northeast of the main stope the vein enters serpentine; to the southwest it enters granitic rocks. So far as indicated by present development, the vein becomes weaker when it leaves the porphyry in either direction.

Sulphide mineralization is chiefly chalcopyrite, pyrite, arsenopyrite, and some molybdenite. The ore has been highly oxidized.

A stope about 100 feet long had been worked 260 feet above the adit level. When visited, stoping had been temporarily discontinued while shaft sinking was in progress.

Stoping had been by square-set methods. The ground was not quite strong enough for shrinkage methods to be used. A cut-and-fill method would have been suitable, but the square-set method, without fill, had proved cheaper because of the abundance of cheap timber in the vicinity. There was little or no pressure on the timbers.

Two stoper machine shifts had sufficed to supply the mill with 30 to 35 tons of ore daily. Direct stoping costs were about $1 a ton; total direct mining costs, including development, were about $2.30 a ton.

The mill flow sheet shown in figure 13 had a capacity of about 100 tons in 24 hours.

Mine ore was dumped into a 35-ton ore bin, from which it passed over a 1-1/2-inch grizzly to a gyratory crusher set for 1-1/2-inch discharge. Ore from the gyratory was elevated to a 1/2-inch vibrating screen, the oversize from which went to a 7- by 12-inch jaw crusher, thence by belt conveyor to a 100-ton ore bin, from which it was fed to a 6- by 6-foot Marcy-type ball mill.

The ball mill discharged through an 8-mesh trommel screen, the oversize from which returned to the ball mill feed. Undersize from the screen passed over a 4- by 6-foot amalgam plate to a Dorr duplex classifier.

Classifier overflow at 92 percent minus-100 mesh passed over a 4-1/2- by 8-foot amalgam plate through a trap and was elevated to two 8-foot Southwestern flotation cells, which produced a final tail and a rough concentrate. This concentrate was cleaned in another 8-foot Southwestern machine, dewatered in a settling tank, and trucked to the railroad at Baker. The following flotation reagents were used:

		Pounds per ton of ore
Pine oil	about	0.4
Crank case oil	about	.4
Water gas tar	about	.2
Lime		6.5

The crank-case oil was from 30 S.A.E. lubricating oil. It was said to have acted as a depressant on serpentine and as a collector. The lime was used as a depressant for pyrite. The gold was chiefly associated with chalcopyrite.

Some trouble had been caused by the building up of sands in the bottom of the flotation cells; this was overcome by a piece of heavy water hose placed along the bottom of each cell. Slits were cut along the upper side of the hose at frequent intervals and the hose connected to the mill water supply. When sand accumulated to an annoying degree, water, under some pressure, was turned on; this forced open the slits in the hose and agitated the sands until they were cleaned out. When the water was turned off, the slits sealed themselves and prevented clogging of the hose with sand.

From 65 to 68 percent of the gold was recovered by amalgamation. About 75 percent of the free gold was recovered on the first plate; the remainder was recovered on the second plate and in the trap.

Total extraction was 95 percent on 0.2-ounce heads. Concentrates assayed $100 to $300 per ton in gold and about 4 percent copper.

Power for mining and milling is supplied by a 240-horsepower Diesel engine, direct-connected to a 225-kw.-a. generator. Compressed air is supplied by a 300-cubic-foot Chicago pneumatic compressor. Fuel costs about $1 an hour of operating time.

Bull Run Mine

The Bull Run mine, about 1/2 mile in a straight line west of the Record mine, was being operated on a small scale by Ed. Sullivan, Frank McCulloch, and O. O. Baisely.

Where exposed by development work, the ore occurred as irregular veins, small lenses, and disseminations in a light-colored fissile argillite.

The mine was developed through an adit by several hundred feet of crosscuts and drifts; a raise had been driven to the surface. Near the top of the raise, a small gloryhole, about 50 feet long, was being selectively mined by hand methods. Ore was dropped through the raise, trammed to ore bunkers, and transferred to the mill in a jig-back aerial tram.

The ore was crushed in a 5- by 6-inch jaw crusher and ground in a 5-foot balanced rod mill. Pulp from the rod mill passed over a 5- by 8-foot amalgam plate to a Wilfley table, which produced a final tail and a finished concentrate. The mill was not working when visited.

Power for milling was supplied by a 25-horsepower Fairbanks Morse Diesel engine. Fuel costs were said to be about $0.10 an hour of operating time.

Orion Mine

The Orion mine, 2-1/2 miles west of the Bull Run mine, is owned by A. V. Lovejoy of Lime, Oreg. It was discovered by Mr. Lovejoy's father in 1903 and was active until 1917. During this period it produced a considerable quantity of free gold from an oreshoot said to have been 60 feet long by 5 to 14 feet wide. The ore mined was highly oxidized. Available information indicates that the original mineralization consisted of veinlets and small lenses of pyrite and arsenopyrite in a shear zone in argillite. The ore is said to have yielded $10 a ton by amalgamation.

The mine was developed by a 280-foot adit drift on the vein, through which the oreshoot was mined, and a 425-foot crosscut about 100 feet lower. Apparently the crosscut missed the oreshoot.

The mine was equipped with a 10-stamp amalgamating mill and a steam power plant.

SUMMARY

Exploration and Development

In 1936 only a few mines had important bodies of developed or partly developed ore in sight. Nearly all the ore shoots from which the earlier production of the region was obtained had either been worked out or had been abandoned and allowed to cave. Consequently, a new operator entering the region is usually confronted with the task of reopening old mines and exploring for ore in the bottoms of old oreshoots or of developing new oreshoots at depth on veins which had previously been productive from ore bodies near surface. In a few cases new veins are being developed.

Deeper exploration below previously-worked ore bodies in many cases may be carried on through long crosscuts as is being done at the Cornucopia, Ibex, and Baisely-Elkhorn; at the Highland-Maxwell it has been possible to gain 1,000 to 2,000 feet of depth by a long drift on the vein.

As a rule, the mines that must be explored through shafts have not gained as much depth below the outcrops as those that may be explored through adits. So far as the writer knows, no shaft has been sunk more than 1,000 feet; the average depth is much less.

Nearly all development is in either argillite or diorite; in a few cases the country rock is greenstone. Crosscuts usually are untimbered, but drifts along the strong fault fissures in argillite or greenstone require close timbering. The amount of timbering required for drifts in diorite depends upon the width of crushed material in the fissure.

Stoping

Although very little stoping was in progress in 1936, it is apparent that the stoping method used will usually depend on whether the vein is in diorite or in argillite or greenstone.

Most of the veins in diorite are on joint planes or comparatively narrow fault fissures where the crushed zone is no wider than the stopes. The dip of these veins is usually less than 60° from the horizontal; they may be worked by open-stope methods, with irregularly spaced stulls for support. In the flatter veins, small mechanical scrapers may often be used advantageously for stope mucking.

The veins in argillite or greenstone usually are on wide fault fissures or shear zones with nearly vertical dip. The wider veins of this type require square sets, which in most cases should be filled. Narrower veins may be mined by resuing.

Milling

In 1936, all mills in the region were using bulk flotation, supplemented in some cases by plates for the recovery of free gold.

There appeared to be little difficulty in making an 85- to 95-percent recovery of unoxidized ore by straight flotation. The use of a unit flotatio
cell in the ball-mill classifier circuit was favored in several mills, but mills that were not using it appeared to be making an equally good recovery i
sufficient flotation capacity were provided in other ways.

The treatment of oxidized or semioxidized ores presented some difficulti
All mills reported an inability to make high recoveries on this type of ore b
straight flotation. A few mills that had made provision for amalgamation pri
to flotation reported excellent recoveries on semioxidized ore; these, howeve
were operating on ores containing a comparatively low percentage of sulphides
It is questionable if amalgamation would be so successful on the heavy sulphi
ores found in some parts of the region. There is, however, little doubt that the free and "rusty" gold could be recovered from the sulphide ores by hydraulic or mechanical jigs either preceding or following flotation.

Mines situated in the inner zone of heavy sulphide mineralization around the Bald Mountain batholith are confronted with the problem of a low ratio of concentration and high transportation costs. Inasmuch as many of the ores in these districts do not contain serious quantities of cyanicides, it may be possible in many cases to cyanide the concentrates at a saving over shipping.

Operating Costs

Exploration and Development

Exploratory crosscuts 5 by 7 feet in cross section were being driven in several places at costs of between $12 and $13 a foot, where this one operation carried all charges; where other work was in progress, the cost of crosscutting was several dollars less.

Drifting costs, including power, supplies, and a proportionate share of the direct overhead where other work was in progress, varied from $5 to $6 a foot in soft ground on fault fissures in argillite, to $8 or $10 a foot in diorite.

Two 5- by 10-foot, 2-compartment shafts were being sunk at over-all direct costs of approximately $40 a foot. One shaft was in soft, wet ground on shear zone in argillite; the other was in comparatively dry diorite. Both shafts were about 300 feet deep when visited.

Mining and Milling

In 1936 the mines of the region were not on a steady operating basis; consequently, mining costs had not yet been determined. Inasmuch as nearly all mines will use one or the other of the principal mining methods mentioned in the paragraph on stoping, it is believed that the following figures will give a rough estimate of the direct costs to be expected. These figures are based on actual consumption of labor and supplies at a number of mines using similar mining methods in various parts of the United States[30]. The costs are computed on the basis of the cost of labor and supplies in eastern Oregon in 1936. It is assumed that operations are through shafts, at moderate depths, and that no extraordinary conditions are encountered.

Cost of square-set mining on tabular veins

Item	Amount per ton	Unit cost	Cost per ton
Labor	4.5 man hours.	$0.54	$2.43
Timber	3 linear feet (round). 10 board feet.	.05 .022	.37
Explosives	1 pound.	.18	.18
Power:			
Compressed air	9 kw.-hr.		
Hoisting	3 kw.-hr.		
Pumping, etc.	8 kw.-hr.		
Total	20 kw.-hr.	.015	.30
Drills and steel			.15
Other supplies			.30
Supervision			.20
Direct mining			3.93
Surface and office			.50
Milling[1]:			
Labor and supervision			.43
Supplies			.35
Power (electric)			.32
			1.10
Total direct mining and milling			5.53

[1] Unit figures are not available on this size and type of mill. The costs given are the average of four mills treating 50 to 200 tons of gold ore daily by flotation. The mills are in northwestern United States.

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[30] Jackson, Chas. F., Summary of Ore-Mining Cost Data: Information Circular 6785, Bureau of Mines, 1934, 47 pp.

There are very few recorded data on the cost of mining open stopes on narrow veins. Such data as are available indicate that from 2.35 to 2.75 man-hours per ton are required, that timber costs are only a few cents a ton, and that powder consumption is about 1.5 pounds per ton of ore. Assuming that other costs are about the same as given above, direct mining and milling costs where open-stope methods are used should be $0.75 to $1.00 per ton lower than where square-set methods are used on veins of comparable size; on smaller veins, costs are proportionately higher.

Freight and Smelting

Freight and smelting charges are an important item in the cost of mining at most eastern Oregon properties. These costs vary from $0.40 or $0.50 a ton of ore mined, in districts where the ratio of concentration is high to $2.50 or more per ton in districts where the ratio of concentration is low.

General Summary

The gold belt of northeastern Oregon includes a number of mining districts, many of which in the past have produced important quantities of gold and silver. Higher prices for gold within the last few years have caused renewed activity in the region. Although there are large numbers of small, weak veins, there are also many strong, persistent ore fissures that have been highly productive in the past and on which there is a reasonable chance of developing more ore at depth. Several companies recently have been successful in developing ore below the bottoms of old stopes.

Nearly all ore bodies are of the quartz-vein type. The veins usually average less than 5 feet wide, but oreshoots on the strongest fissures are persistent. Although many individual oreshoots have been worked out, the bottom of commercial mineralization in the region has not been reached. The average gold content of ore mined in the past has been over 0.5 ounce per ton; it is probable that higher gold prices and lower operating costs will make possible the mining of lower-grade ore. Unless large ore bodies are developed on the copper-gold veins in greenstone or in the Cracker Creek district, there are no known opportunities for large-scale gold mining in the region. On the other hand, most of the more attractive opportunities are not generally suitable for very small, weakly financed operations. Except in the districts where there are small, high-grade veins, an extensive exploration and development program is usually necessary before production can be maintained on a steady basis. This is because nearly all the strongest veins have been mined near the surface.

Operating conditions vary considerably in different parts of the region. As a rule, an abundance of water and timber is found in the districts of highest transportation costs, and vice versa. Reasonably priced electric power is available in many of the most important districts. In general, overall operating costs are moderately high.